Granular Synthesis

Fourier and eternity

Since Fourier and von Helmholtz it has almost become a matter of course: sound is a sum of sine waves, all with their own frequency, amplitude and phase: an analogue perpetual continuum. However, sounds, sounds do not last forever ...

Long sounds

But, back to Fourier. From a mathematical point of view sine waves have no beginning and end. They therefore exist only on paper and in heaven where everything is eternal. Fourier was talking about periodic vibrations. These are vibrational forms that repeat themselves and of which each period is an exact copy of previous and future periods. Long lasting non-changing sounds can best be described according to Fourier's eternal model.

Short sounds

The shorter the sounds the more difficult it becomes. Imagine you hear one click. You now need some mental gymnastics to describe this sound according to the Fourier model: you just pretend that the corresponding click is a periodic signal, just as if the click is repeated exactly every second. So, now we have brought eternity into our home, even without Our Good Lord. Our sound now has by definition a repetition frequency, a periodicity, of one vibration period per second.

Then it is simple in one go according to the Fourier analysis. Our click sound is a sum of sine waves that relate in frequency to the sequence of natural numbers: 1, 2, 3, ... each with its own amplitude and phase value. Nice brain trick exercise, but for the practice of synthesis it doesn't work out. Let's recreate this click according to the additive synthesis model derived from Fourier. We now need a lot of sine wave oscillators: the lowest with a frequency of 1 Hz, then one of 2 Hz, and thus a very long row to go. All together synchronously in a mixer and then: one click per second…

Sound as a succession of micro sounds

All the more reason to reflect on a sound model based on finity. Sound built up from finite micro-sounds, banded together into one sound. Like a molecule: made up of atoms. Rather a particle model, then a wave model.
I mean the theory of Dennis Gabor from 1946. But before going into the analysis model of this later Nobel Prize winner for physics (1971) for the invention of holography, first let's remind that my compatriot Isaac Bee(c)kman already came up in 1616 with such a particle theory about sound.

He explained this theory on the basis of a vibrating string. The string vibration chopped the air into pieces, which propagated in all directions as a sort of sound particles. This is still a very nice compact metaphorical description of synthesis models that only become reality much later in the twentieth century: Pulse Forming Synthesis (Schumann, Fricke, Voigt), VOSIM (Kaegi), FOF (Xavier Rodet).

All sound models based on micro sounds that are welded together into one unit. What these three synthesis models have in common is that these sounds are built up from micro sounds with a repetition rate of the pitch of the desired sound. Low and high sounds can thus be made up of the same micro sounds. The difference is in the 'rest' between these micro sounds. The timbre of these sounds is largely related to the vibrational form and duration of these micro sounds.

Dennis Gabor and his granular sound model
Gabor also wondered if you could consider sound as built up from micro sounds. Not only from micro sounds with different repetition frequency depending on the pitch, but with very short micro sounds of uniform duration. Gabor's model was rather an analysis model than an synthesis model. He was looking for data reduction because of the small bandwidth of the telephone connections in the 1940s. Later, the composer Iannis Xenakis got acquainted with the work of Gabor and realized that this theory offered a perspective for electronic composition and sound manipulation. He was the first to bring Gabor's theory into sounding (analogue) practice. The first digital implementation of Gabor's ideas is from Curtis Roads (1975). Another 'granular' composer from the very beginning in the digital domain is the Canadian Barry Truax. At the moment, granular techniques are very popular mainly as a sound processing model of samples. For example, Reason’s Malström is such a granular synthesizer combined with wavetable synthesis.

`GrainStream.pch2`, the Granular Synth patch

1 PERIODICITY
LfoShpA is the oscillator that triggers the grains, the short sound fragments, via the RndTrig module. This oscillator is set to 49 Hz. In one second almost 50 grains are triggered.

2 DENSITY
The trigger oscillator LfoA is connected to the RndTrig module. How much of the input is passed to the output is manually adjustable between 0 and 100%, but can also be controlled externally.

3 RANDOMNESS
With the noise generator Noise and miixmodule Miix1-1A, the tight periodicity of the trigger oscillator can be provided with irregularity.

4 PITCH / SCALE

In this block, the frequency or the pitch of the grain oscillator OcsShpA is controlled.

5 WAVESHAPE
By means of waveform and shape% control the basic dimension of the grains can be determined and modulated.

6 ENVELOPE
In this block, the grain oscillator is provided with an envelope by means of ModADSR. In Granular Synth about 50 grains, sound fragments, per second are played. The duration of the envelope, 19.4 milliseconds (attack + release time = 9.7 + 9.7), is related to this. With the Release Time control input the envelope duration can be modulated.

7 AMPLITUDE
The global amplitude is controlled in the ModAmt module. With selector SW2-1 it is possible to determine with which control signal the volume is controlled: with S & H output, or with the Fade output which is formed by a Glide module, used here as a simple attack release envelope generator.

8 PANORAMA
This block forms the automated panpot. It consists of a Pan and ModAmt module.

FX and Output
In the FX Area you will find the Reverb module, a global effect for the total signal. This saves a lot of dsp power; placed in the Voice Area it would be calculated as many times as the number of selected polyphonic voices.

GrainStream, control

Central to the control of Granular Synth's parameters are 2 LfoAShpAs and an S & H module.

One LFO (10) is sampled in the S&H. The sampling commands were delivered by the output of the RndTrig module in the DENSiTY block (2). The S&H (9) output is passed as a control signal to blocks 1, 4, 5, 7 & 8 of the Granular Synth.

The control input of blocks 4, 5, 7 & 8 runs via a ModAmt module that can be controlled with the other Lfo (11). This LFO (11) is also directly available as a control signal for RndTrig module and for the Pictch control input of the grain oscillator (5 OscShpA).

With Lfo (11) the global course and the duration of the course is set. The course depends in part on the frequency of the other LFO (10).

Patches & tweaks
In addition to the static settings of the Granular Synth, the main tweaks concern the following parameters: frequency and waveform of both LFOs, the outputs, and the quantity of these, to the various synthes blocks.

GrainStream-2 and further patches are extensions and combinations of GrainStream-1.

NMG2Demo & NMG2 Hardware
All patches can be loaded both in the demo and in the hardware. The big difference: in the hardware they are polyphonic, up to 15 voices if you have dsp expansion. By also connecting the RndTrig and the LFOs to the keyboard (25, 50, 75 or 100%), massive asynchronous layers and clouds are created.

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sources

internet
www.granularsynthesis.com/
www.sfu.ca/~truax/
http://icem-www.folkwang-hochschule.de/~ludi/singapore/singtutorial.html
everything about the NMG2
4all.nl/~rhordijk/G2Pages/index.htm

literature
Granular Synthesis of Sound
Curtis Roads
Foundations of Computer Music
Edited by Curtis Roads and John Stawn
1985 MIT Press
ISBN 0-262-181142 hard, 0-262-68051-3 paper
(Originally published in Computer Music Journal 2 (2): 61-62, 1978)