Percussion!

Physical Modeling Percussion Synth with Delay Line and All Pass Filter

At first glance it may seem strange to have a delay line as the basis for percussion sounds. Percussion sounds are generally seen by a non-harmonic overtone structure. Up to now, we use the delay line in the form of a comb filter as a harmonic resonator for generating string and wind instrument sounds.

All pass

all pass: all frequencies are allowed to pass, but not all at once
The peculiarity of such an all-pass circuit lies in the fact that different frequencies are transmitted with distinct delays. This phenomenon, known as dispersion, introduces increasing delays for the lower frequencies. We are going to get acquainted with it now.

The inharmonic resonator

The harmonic resonator was already known: simply a delay line with adjustable feedback, a comb filter. Instead of this direct feedback of output from the delay line to input, we now feed back indirectly via an all pass filter. Because the all pass is now in the feedback loop, the dispersion effect becomes really clear: every harmonic frequency from the comb filter now has its own distinct delay. The spectrum is thus pulled apart and thus becomes inharmonic.

Controls

We can now regulate the degree of inharmonicity with the frequency of this filter (in our case the Semi (tone) parameter of the Osc String that serves as a delay line) in relation to the pitch of the harmonic resonator, the comb filter, and on the other hand with the degree of feedback, ± g, on the all pass filter. To give the whole thing more possibilities, a low pass filter is also included in the output of the all pass filter. If we open this filter completely, we have the original Schroeder all pass network again. With activated low pass this circuit is called an absorbent all pass network or all pass filter.

`Percussion-1.pch2` synth

As far as the sound-shaping part is concerned, this synth is almost entirely composed of delay lines supplemented with a noise and envelope generator. It consists of three global parts: 1. Excitation Strokes and 2. Resonator, which together form the actual virtual percussion, supplemented with 3. eDrummer, the virtual player that generates the rhythm and provides the more refined controlling as distinct strokes and their positions of attack on the object (sheet or otherwise).

1. Excitation Strokes

Here the different types of stops and places on the sheet are simulated. The starting point is a noise generator that is followed by a comb filter. After the

comb filter, this signal passes through an envelope generator, which makes it possible to determine exactly the switch-off time. That is not a luxury, because with a high feedback setting of the input comb filter, there is obviously also a long decay. Without this envelope generator, this would already result in a kind of picked string sound. Now, by such an envelope, the input signal to the resonator can be shortened such that it is indeed credible (short) attacks. Finally, two more Level Amps with which the signal volume can be adjusted as desired.

2. Resonator
This involves the actual object being struck and, as already stated, is made up of a comb filter with an (absorbent) all pass filter in the feedback loop. In both filters, the core element is therefore a delay line in the shape of an OscString module. This has the advantage that the delay times can be set on the basis of note numbers; that work a lot more insightful than working with a DlySingle object where you set the length of the delay in (milli) seconds.

3. eDrummer
The heart of this virtual musician forms an LfoA, which provides a continuous Pulse at the desired tempo. However, complete predictability is death in the pot. That is why this pulse serves as an input for an Rnd Trig module. You can set here in percent how many pulses are passed. However, this can also be influenced with an external modulation source. The outgoing pulses from the Rnd Trig module then activate the sample command input of an S & H module. A second LfoA, Pattern is used as a signal to be sampled. If the frequency of the pulse is identical to the frequency of the Pattern Lfo, a sample will be taken at the same point in the output waveform of the Pattern Lfo and sent to the output of the S & H. Not very exciting so: that results in one and the same value. However, if both frequencies run out of step, it becomes interesting. Now and again samples are taken at other locations in the output of the Pattern Lfo. The output of the S & H can be quantized in a KeyQuant module in a desired scale, scale.

A film phenomenon for explanation
This patch has a nice counterpart in the visual world. The same principle that you often saw in a Western movie. The camera films a galloping couple of horses pulling a car with wire wheels. Not infrequently, despite the speed, you saw that the spokes slowly moved in the opposite direction. Or slower ahead than you expected. The camera makes 25 frames per second, you can imagine them as sample assignments for the S&H module. The spinning spokes now represent the different phases in the output waveform of the pattern Lfo. The camera operates at a fixed frequency of 25 shots per second. The speed of the horse car is of course not constant. As a result of this speed, interesting moving patterns of the wheel spokes arise, both forwards and backwards at different speeds.

Thanks to Synapse magazine
I first encountered this sequence patch in the middle of the seventies in Synapse magazine, an American synthesizer magazine. He was awarded to

Roger Powell, then the synthesist of Todd Rundgren'xcs Utopia. Powell used an analogue sequencer and an S & H module for this.

The sample and hold module samples the output from the running sequencer. If you now ensure that the two do not run on the same frequency, interesting changing patterns will arise. Generating exactly the same patterns did not happen in that analogue era.

Typically such a beautiful patch that arose from the hardware limitations of that time. An 8-step sequencer and a separate S&H in those days: then you had something! In that time I have often applied this principle with my 2x8-step Oberheim Mini Sequencer and the sample and hold in my modularized Arp Odyssey.

Even more possibilities with G2
And now again with the G2. Because now everything is happening in the digital domain, this patch has become even more interesting than it already was. Now You can synchronize all involved frequencies exactly to each other. And in this way realize precise reproducible sequences.

With the G2 you can program from genuinely reproducible fixed static loops to varying patterns over 699 seconds (even a lot more via freq control input). (To clarify this sequence principle, open the `S&H-Sequence-1.pch2` patch and listen and study the variations.)
Besides `Percussion-1.pch2` you also find a second variant, `Percussion-2.pch2` synth. This is almost identical to the first in the settings of eDrummer, but with different settings for the synth. They give you a good impression that with some tweaking you can quickly come up with completely new fantasy (percussion) sounds and/or loops.

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Internet links

https://valhalladsp.com/2011/01/21/reverbs-diffusion-allpass-delays-and-metallic-artifacts/

https://en.wikipedia.org/wiki/All-pass_filter

mp3 demos from, among others, the Korg Wavedrum
http://virtualacoustic.free.fr/HTML/Demos.html