

Creative Physical Modeling Toolbox for Reaktor 5

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Introduction

This PhM Toolbox is based on so called 'Modal Synthesis'. That is to say: it is based on the exciting of modes of vibration (or resonances). This method is especially used for pluck & struck instruments (Guitar, Harp, Marimba etc.). But this toolbox offer you also a method for creating all kind of wind instruments, plus keyboard instruments like Clavinet, Organ and Electric Piano.

But there is more (and rather unique): in stead of working with prefab resonators (one for plucked strings, one for mallets, etc.) you have totally control over every aspect of a resonance. There are also a lot of 'overall' parameters for decay, release, mass, stiffness, nonlinear behavior, etc.). Because everything works in real-time, it's even possible to morph from a guitar to a gong and back (to mention one example...).

I have included a massive library of ready made instruments, but because of the freedom in programming which the resonators you offer, you will also be able to make your own. That's why I use the word 'creative'.

How a pluck/struck resonator works

In fact, when you know the working of one pluck/struck resonator, then you know them all. Let's take a look to an overview of this type of resonator, the one with the most parameters. I suggest that you open the Sitar (in the folder Plucked Strings Ethnic). First let's take a look to the excitation (without excitation, no resonances....) As you can see, I use a sample player as source, in which you can load every excitation file you want. It's important to realize that the sound of the resonator changes when you change the frequency of the excitation file. Take a simple impulse: when you set the frequency low, you will hear more pronounced low frequencies in the resulting sound. And vice versa. It's even so that when you use a guitar body impulse response as excitation, the resonator 'takes over' some frequencies of the guitar body sound - this is called commuted synthesis.

It replace the need for a second resonator (prepared as a guitar body filter) which costs of course extra CPU usage.

As you see, I also use an extra Noise burst, for when you need some extra high frequencies.

Let us now take a look to the resonator, which has lots of parameters. First the modes (or resonances). How can you get the sound of a Sitar? Here is the trick: I have first made a sample from a Sitar tone, about 2 seconds long. Next I have made a spectrum analyses of this tone. (I use PRAAT which is a free downloadable analyzing tool, developed at the University of Amsterdam. Once you have a spectrum you can even listen to separated parts of the resonances!) Well, now you can 'rebuild' this spectrum in the resonator. However: you don't see frequencies (as in the spectrum) but 'Ratio's'. So in stead of filling in 100, 200 and 300 Hz (for the first three resonances), you can set the ratio's on 1, 2, 3. The same for 150, 300 and 450 Hz, so it does not matter which are the exact frequencies. Ratio's only give the relative relationship between resonances. A rule of thumb for strings is a ratio serie of 1,2,3,4,5,6,7,8 etc. What makes strings sound different are the amplitudes of the resonances.

Let's now take a look to the 'overall' parameters.

Properties of Material

In this section you can specify timbres like metal, glass, wood. Especially the parameter 'Stiffness' plays here a big role. Turning to the left, you will hear slow decaying high resonances. When you turn the knob to minus, high resonances even decaying slower then low resonances. The opposite is happening when you turn the knob to the right. High resonances are decaying very fast. The stiffness parameter makes the difference between metallic sounds (left) and woodlike sounds (right). Concerning guitar sounds: when turning to the left, you get steel strings, a bit less left you get nylon nylon strings. Of coarse here is a relation with the parameter 'Damping', but this parameter has also to do with the decay behavior of high and low keyboard notes. Turning to the left, high notes will decay relative long, while low notes will decay relative short. Turning to the right gives the opposite result. You can 'fine tune' this behavior with 'KB Tracking'.

The parameter Mass has to do with inharmonicity (the more mass, the more inharmonicity), which is also close related to stiffness! With this parameter you

also can change a string into a gong - in real-time!

However: when you turn the knob to whole nummers (1,2,3) , then you change the timbre of the sound, that is to say: a string sound stays a string sound, but with a bit different timbre.

Next section: I think 'Decay' and 'Release' speak for themselves. The same for 'Trans/Tune'. The parameter timbre works only in certain cases, depending of which resonances are active.

Nonlinear Bending

Let's now take a look to the parameters for string behavior, under the head 'Non-Lin Bending'.

Tension has to do with the tension of the string. When you pluck a string very hard, then you will notice (in real life!) a short pitch bending. You can get this behavior with the help of the parameters Pitch Bend, Freq and Smooth (the latter handles the smoothness of the bending. The bending effects are hardly to describe, because you can set rather extreme values - so try them out! (for a first listen impression load the patch 'Spooky Voices' from the folder 'Various': hold down a pressed key and listen...)

The parameter Scattering simulates some sort of distortion, for instance when a string hits a fret, which coarses extra high frequencies. All these parameters are velocity depended.

Recently I have added a second serie of parameters under 'Ethnic' (see Sitar2). With these parameters you can add quickly a 'Eastern like' sound quality. BasicString and Scattering are in fact parameters which 'mix' the sound of the basic string with the Eastern like sound. This adds a lot of high frequencies, with the Low Pass filter you can reduce them. (I have done a spectrum analyses: instead of 16 modes, I counted 40 of them!)

More recently I found a way to create string scattering (tension) which sound very natural (see Sitar3: there is only one parameter called 'StringTension' for pitchbending en scattering! - BTW: the resonances are switched on lowpass, to obtain this string effects)

Pluck/struck resonators types

Some notes about the differences in pluck/struck resonators types: in the folder 'Various' you will find a patch called 'GuitarBody'. Here the resonator has fixed resonances in frequency for very precise tuning). There is also a resonator made for percussion: it has frequency in ratio's, but with much smaller ratio-steps. In the folder 'Percussion' you will find the patch 'Percussion' which is 'tuned on the first 14 modes of a circular membrane. Finally: some 'Gong&Bell' patches uses a resonator in which you can set only the amplitude of each resonance. It is in fact one of the first resonators that I have created for this toolbox. The reason that I have included this one, is that the inharmonicity parameter creates very good gong/bell sound (turned to the right), while you also can create membrane like sounds (turned to the right) The overall parameters just discussed are not available. The number of modes variates from 16 to 40 (only for plucked strings: see the AcousticGuitar)

How a windbore resonator works

Basically not very different from the pluck/struck resonators. The main difference is that a sound can be sustained by a feedback value. Round value 0.1 (FB-Level parameter) you have a suitable value for creating all kinds of woodwind instruments (Clarinet, Oboe, Flute, Organ, etc.). However: you can also experiment with 1 or 2 resonances and a much higher feedback level. This method allows you to create easily extra high harmonics. I have used this method for some Saxophones and the Trumpet. You also may want to experiment with the library instruments as a depart and set the ratio's on other values, also values like 1. 2.75, 3.5, etc.! (BTW: on the internet you will find lot's of papers about differences in harmonic series between open (Flute) and closed (Clarinet) pipes.

Beside 'Pressure' for controlling the airflow (the more pressure, the more high frequencies) there are also parameters like 'Overblowing' and 'Timbre'. 'Overblowing' don't works in any case: it depends of the spectral content of the resonator. This is about the same for 'Timbre'. Generally spoken: these parameters works fine with instruments like Clarinet and (ethnic)Flute. When you use Timbre (via a midi controller) you will notice not only a pitch shift, but also a gradually change in timbre.

A very interesting experiment is putting a pipe in a pipe! At this way I have constructed the Didgeridoo, but while working to create this instrument, I discovered numerous other wind instruments.

A separate case: FOF (Formant Wave Function).

The library also contains a FOF Synth. A FOF is based on a harmonic oscillator (a damped sine-wave, excited by a (im)pulsetrain.

This creates particular sidebands round the center frequency, which are perceived as a formant (a peak in the harmonic spectrum). Some instruments have very pronounced formants, like the human voice, but also a trumpet and bowed strings. For good simulations 5 formants are adequate (one FOF bank). Again you can use PRAAT for a formant analyze. Parameters of a FOF are (center)frequency, bandwidth, amplitude and transpose. Next you will see the pulsetrain parameters, which speak for them selves. There is one overall parameter: formant shift. With this you can create formant variations(like 'oe', 'a', 'i').

Beside the FOF Synth for sustained sounds, the Folder 'FOF' also contains a FOF Percussion patch. Handdrums, bell and glass sounds are easy to create.

Here is following a list of instruments per folder

Bounce/Roll/Scrape

Lots of this types of sounds divided over 7 patches.

Bowed Strings

-Cello/Violin

-Violin Pizz

Brass

-Trumpet

-Dulcimers

-Koto

-Various (lost of eastern sounding instruments)

FOF

-Human Voices

-Cello/Violin

- Flutes
- Percussion
- etc.

Keyboard

- Accordion
- ChurchOrgan
- Clavinet
- Electric Piano
- Hammond B3
- Harpsichord
- Ondes Martenot
- PipeOrgan(Little)

Mallets

- Marimba
- Xylophone
- Clockenspiel
- Gamelan
- Vibraphone

Percussion

Numerous percussion instruments,
like (bowed) Gong & Bells, Churchbells,
Bongo/Gonga, Kick. Snare, Tabla, Random Perc,
Windchimes, Waterphone, etc.

Plucked Strings

- Fretless Bass
- Guitar(Nylon)
- Guitar(Steel/Strum)
- Guitar(Electric)
- Mandoline,
- Lute
- Harp

Plucked Strings(Ethnic)

- Sitar
- Sitar2

-Sitar3

-Tanbur

-Thumb piano

Various

-Bow&Blow(See presets)

-Convolution

-MovieSounds(See presets)

-GuitarSoundBody

Spooky Wistles/Voices

Woodwind(Ethnic)

-Bagpipes

-Bansuri

-Didgeridoo

-Ney

-Panflute

-ReedFlute

-Shakuhachi

WoodWind(Medieval)

-Shawn

Woodwind(Western)

-Flute(standard)

-Piccolo

-Recorder

-Reed(Various - Clarinet, AltoSax, Oboe, Bassoon)

-Sax(Soprano)

-Sax(Tenor)

