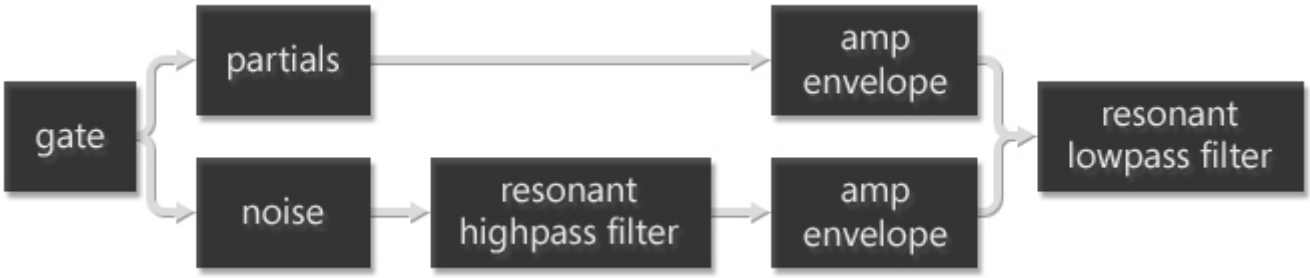
Modal VST

1d and 2d modal synthesizer by xoxos

Modal VST is the square counterpart to Radian VST. The same synthesis technique is used to render the partials of a 2d square plate. Circular membranes being, of course, more widely known for instrumental applications.

The modeling technique also lends itself to synthesis of the dense 1d form, most notably for bass strings. While the timbre may be emulated to some effect, note that the constraints of this application are geared towards percussive applications.



Architecture

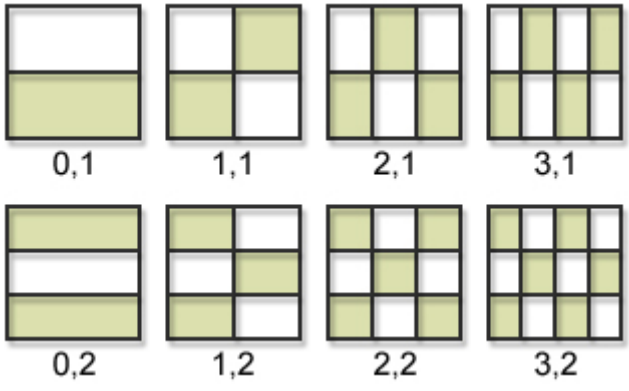
The signal path consists of two parallel paths as illustrated. The distinctive timbre is produced by a bank of sine oscillators as in Radian VST. This is augmented by a highpass filtered noise generator. Each component is amplified separately, then the signals are mixed before being routed to the lowpass filter and trimmed by the global amp amount.

The sine oscillators are an efficient mass-spring algorithm that produce a pure sine with an exponential amplitude decay, which is ideal for modeling percussion. This algorithm reacts adversely to most modulation, so most coefficients are only read at NoteOn events.

2 Dimensional Plates

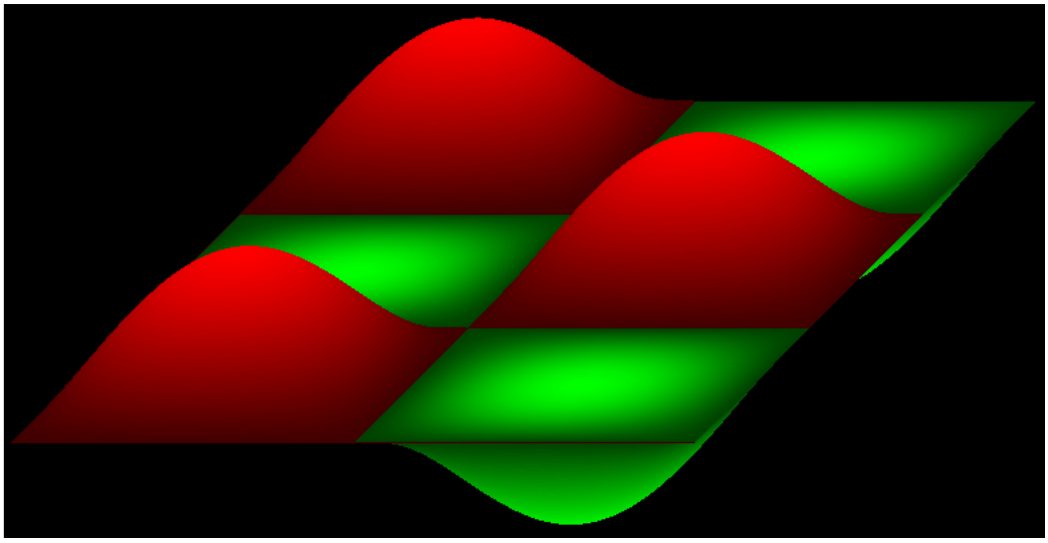
Each partial frequency is associated with a mode of vibration. As in the circular plate, many modes of vibration are supported simultaneously. The lowest frequency, or fundamental, is produced by the entire plate flexing in unison.

Modes are described by the number of horizontal and vertical divisions between oscillating sections, the fundamental is annotated as 0,0. One horizontal division is annotated as the 1,0 mode of vibration.

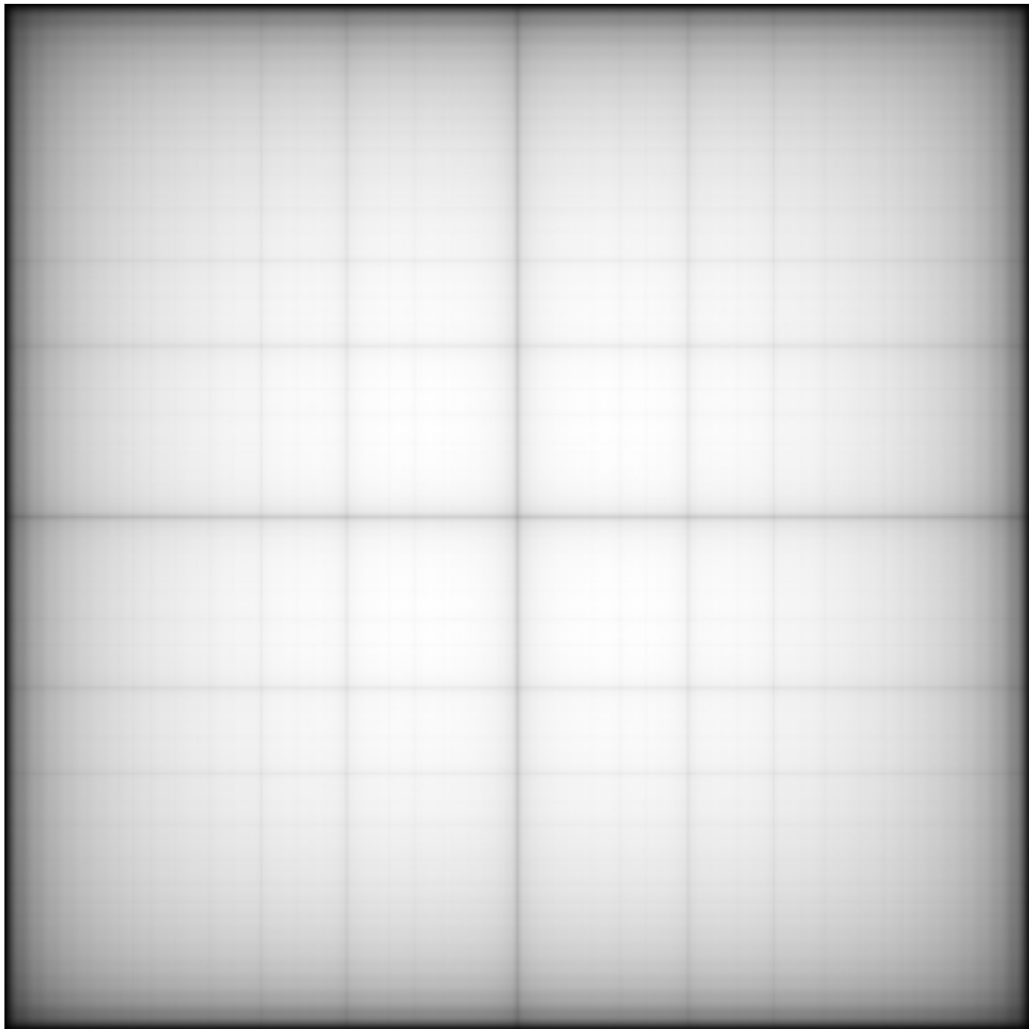


Striking the plate directly in the center would not excite the 0,1 mode, but would excite the 0,2 mode of vibration. An impulse located closer to the center of a region will elicit a stronger response in that mode.

The striking position is translated to excitation of each mode using Fourier analysis, and in the same way that Fourier analysis can be used to describe a period of a signal, the Fourier representation can also describe any shape the vibrating plate adopts.



An illustration of the 1,2 mode of vibration



Where to strike a 2d plate..
The lighter the area, the louder the harmonics (mapped to 63, 63)

1 Dimension

The construction of this VST opportuned implementation of a 1 dimensional model as well, which is most conveniently applied to synthesis of strings (or perhaps thin bars or tines). The same fourier analysis is used to translate striking position to the amplitude and phase of partials. The emulative strength of this will be evident if a guitar string is plucked in the center, which will produce a timbre similar to a square wave, lacking even harmonics (harmonics are numbered from 1 at the fundamental instead of 0 as vibratory modes are).

Because the construction of this instrument is oriented towards percussion, emulation of stringed instruments is limited.

Polyphony

Radian VST allowed the maximum number of partials to be set from the gui as a means of controlling cpu usage. Modal VST fixes the maximum number of partials at 256 and uses adjustible polyphony to control cpu resourcing.

Modal VST debuts a new polyphony scheme, which allows the user to select from 1 to 4 voices. Polyphony functions differently in 1d and 2d modes: in 1d, retriggering the same note will be applied to the same voice, whereas in 2d, retriggering the same note will be applied to a free (or the oldest) voice, so that the same pitch can occupy more than one voice of polyphony in the 2d mode. The 1d scheme is intended to be more emulative of acoustic instruments, whereas the "synthesizer" polyphony in 2d mode allows for "multiple objects" to sound and decay over each other if only one pitch is used and triggered repeatedly. Intending a single object in 2d mode can be accomplished by limiting polyphony to 1 voice.

In 1d mode, the most condensed arrangement of partials uses less than the 256 count for most notes, so that until the bass range is played, notes will use less cpu. In 2d mode, all but the highest pitches will use all 256 partials, so that limiting polyphony to 1 is prudent.

Parameterisation

Performance is alternated between 1 and 2 dimensional modes by the **mode** button, on the left side of the gui. The top left panel of the gui can be toggled between displaying two sliders for the **X** and **Y** position, or a **joystick**. Either form may be used for 1 or 2 dimensional modes.

As in all xoxos VST, knobs situated under sliders trim the velocity responsivity of the parameter (either expanding around the setting or between the current setting and the minimum). Buttons located under some sliders expand the range.

The **decay** slider ranges to 10 or 50 seconds. The decay of increasingly higher partials may be attenuated at a faster rate to more effectively model most materials.

The **stretch** slider increases the distance between the partials, modeling increasingly stiffer material until the timbre more resembles a block or bar. The **bright** parameter affects the gain of higher partials.

Striking Position and Coupling

The coupling slider serves a different function in each mode.. this may not make much sense from an end user perspective, but it made sense from an instrument designer perspective... :) This may need to be read a few times..

In the 1d mode, the X slider (or the horizontal joystick position) indicates the striking position, ranging from the end of the "string" to the center. The coupling slider adds the sum of the partials to the input on the next sample.. the effect of this is an increased sustain than can sound very natural (and "probably won't" explode if you leave it at the infinite setting). Combine the decay setting with the coupling setting for a more realistic sustain on plucked/struck string patches.

In the 1d mode, the Y slider blends the partials between the gain indicated by the X slider position (maximum setting) and a gain of 1 for all partials (minimum setting). If you set Y slider (or Y position on joystick) to 0 in 1d mode and use no stretch, it will sound like a sawtooth oscillator.

Using a small amount of this function (eg. setting the Y slider to 9/10ths or so) will increase the volume of partials cancelled by the striking position, which can be used to emulate excitement of these partials caused by nonideal conditions, eg. sympathetic vibrations or nonrigid boundaries.

In the 2d mode, the coupling slider serves the same purpose the Y slider serves in 1d mode.. it crossfades the gain of all the partials between the position and 1, eg. putting the coupling slider at max. in 2d mode will make the same sound regardless of the joystick position, and putting the Y slider at 0 in 1d mode will also nullify the position setting.

Pitch Envelope

The far right of the partials panel contains decay rate and envelope amount controls for a pitch envelope, which can be used to emulate pitch modulation produced by loose boundaries or more synthetic percussion effects. Lower settings can be used for very fine adjustments.

Noise Panel

The noise generator is extremely conventional and probably needs no explanation. White noise is passed through a resonant highpass filter that can track the keyboard. The amp envelope is separate from the partials attack/release envelope. It is intended that slower attacks can be used for the partials section while the noise generator is used for the attack portion only.

The exponential decay falls until it hits the sustain level, then the noise decays at the same rate as the partials. Using a frequency analyser will indicate that the partials only extend up to samplerate/4, or half nyquist (11025 Hz if your sample rate is 44.1kHz). This is due to the instability of the mass-spring algorithm beyond this point (thankfully, or the cpu of partials to nyquist would be sky high). Depending on the timbre, the highpassed noise sustain can be used to balance this frequency shelf to some degree, though I expect most percussive timbres won't sustain long enough to make a difference.

The noise is intended to augment the attack portion. If for some reason you set the noise decay rate to exceed the partials decay rate, the noise will decay at a value between the two settings at that point.

Quirks

This is one of the more idiosyncratic instruments I have crafted. It was intended to be a less used but completeist counterpart to Radian, since I don't foresee people wanting to emulate square percussion as frequently, though now it seems that the 1d model will draw users due to the bass emulation.

I didn't foresee having to prepare a new polyphony handling algorithm for this fairly trivial synth..

I thank Perry Cook of CCRMA for the formula for the frequency of partials of a 2d square. It sounds right. While the Fourier translation of striking position is a fairly trivial matter, the build brings about some points:

At a max of 256 partials, the model only extends to 16 * 16 vibrational modes, which is only a few octaves above the fundamental frequency of the plate without partial stretching. Note that reciprical modes (eg. 2,4 and 4,2) have the same vibrational frequency.

One issue users will notice is that sustained 2d timbres, especially with partial stretching, often have a cyclic ~LFO sound to them, which often seems to either rise or fall. I am not sure what causes this.. if it's an artifact of phasing between modes that are close in frequency due to stretching. I think people will expect me to be, as I coded it, but as is often the case, the ability to produce something doesn't facilitate empiric knowledge of the topic. There is certainly no pitch modulation in the algorithm so it is an artifact of the arrangement.

I am wondering if it is also possible that these sounds are endemic to square membranes, eg. Rolf Harris' wobble board sounds.. this illustrates my previous statement nicely, in that while I am outfitted with a platform for coding, I am not outfitted with a selection of materials to form square plates from and percuss them. Perhaps most square objects don't have the sustain necessary for observation of low frequency cyclic oscillations produced by them?

A quirk regarding the 1d form.. and perhaps obvious. Demonstrating the early recordings of the 1d bass emulations (heard in preset 'bass 1') elicited comments like "that sounds like my Rickenbacker!" - I think compared to most synthesizers, Karplus-Strong models et c. this instrument has a fair capacity for bass emulation. The first time I chucked the VST in my sequencer I noticed that the bass sounded out of tune. I attempted to compromise the partial stretching (heard in preset 'bass 0') and am at this point undecided.. the fundamental is in tune, should I drop it to balance it out a bit, or, in other words, why do the stretched partials sound so good, and so bad?

These are the things one encounters as a VST developer. I consider myself to be a fairly honest person, or at least I realise that an attempt to conceal these less attractive facets of the model wouldn't be shrewd. Some 2d settings don't have overt oscillation, and some compromise can be made to the bass timbres, and as I don't see any sensible solution to either characteristic (as they may be innate to the forms) I am content to leave the model as it is at this point and proceed to the next project :)

There is no expression of guarantee, please demo before purchase. Modal VST was created with the SynthEdit SDK - www.SynthEdit.com
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