Werner Kaegi’s VOSIM

Isaac Bee(c)kman

In 1616, this Dutch scholar presented a theory of sound. He imagined that a vibrating string cut the air into pieces according to the frequency of the string vibration. These pieces of sound radiated in all directions and provided a sound sensation in the ear. Bee(c)kman's model was thus a particle model rather than a wave model. Although his theory has been overtaken by current insights, it is a nice metaphor for the various formant synthesis models such as FOF, Pulse Forming Synthesis and also VOSIM.

In all these models it means that one or more consecutive pulses with a fixed duration and with a rest period are triggered with a periodicity of the desired pitch.

VOSIM: Werner Kaegi & Stan Tempelaars

Both Kaegi and Tempelaars were part of the staff of the Institute of Sonology, University of Utrecht during the seventies and eighties. In the early seventies, the Swiss composer and scientist Werner Kaegi researched speech sounds.

Kaegi's research into the essence of speech sounds has resulted, among other things, in his Vosim sound synthesis model, which he further developed together with Stan Tempelaars and later published in 1978 in the professional American press. The name Vosim is derived from *Vo*ice *Sim*ulation.

In 1967 Kaegi became acquainted with the sine^2 pulse and its spectral characteristics. As early as 1966 he had the idea to develop a sound synthesis model based on these sin^2 pulse signals. Ultimately, this results in one or more sine^2 wave pulses in succession with the same or decreasing amplitude, followed by a rest period. That is one Vosim time function, detailed controllable by means of 12 parameters (see 1-VOSIM function). Such a Vosim-time function can be imagined as the smallest micro-sound from the Vosim repertoire, a quantum, or grain.

It forms the basic building block for all sounds synthesized in Vosim. The sound character of such a grain depends on the number of pulses, the duration of those pulses and whether or not they decrease in amplitude. But also whether or not such Vosim time functions are triggered in the time or pitch domain (faster than about 20 times per second).

Vosim impulse trains triggered in the rhythm domain

Load simple `VOSIM-1.pch2` and listen to the first four variations. You now hear short percussive sounds twice a second, followed by an 'uu', 'oh','o' and' ah sound character. This short series of sine^2 wave pulses are characterized by both a vocal character and a pitch impression.

If we make the Vosim functions longer, more successive decaying pulses, we hear clearly a dying sine wave tone. Listen to variations 5 to 8.

Vosim functions triggered in the pitch domain
Open `simple VOSIM-2.pch2`. Now you can hear what happens when you trigger the Vosim functions in quick succession so that the trigger frequency itself produces a pitch sensation. The fast pieces of sound follow each other so quickly that our observation system can no longer follow them separately. The discrete sounds in the time domain now integrate into a continuum: a pitch and timbre experience. We have now acquired two intertwined 'periodicities'. The trigger periodicity now determines the pitch of the resulting sound and the frequency of the pulses is decisive for the timbre.

In variations 1 to 4 you always hear the same low tone, E (MIDI note number 40), but with a different vowel dimension: again the familiar sequence, 'oo', 'oh. 'ò' and 'ah'. Variation 5 shows what happens when the frequency of the sine wave pulses is modulated, while the pitch remains the same: you now hear the wah effect, moving back and forth between the vocalities 'oo' and 'ah'.

If we keep the frequency of the pulses equal, but modulate the trigger periodicity, sounds can be generated with different pitches but with the same formant or vocal quality. In example 6 you can hear a siren with a clear 'ah' sound character. In variation 7 the pitch is randomly modulated, but the frequency of the sine square pulses remains fixed at approximately 3000 Hz.

Patch `simple VOSIM-3.pch2` again shows 8 variations of various modulations of fundamental frequency and formant frequency. These examples show that with one Vosim function you can only achieve sounds with one formant. How strong that formant is depends on the number of pulses and their possible amplitude decrease within one Vosim grain.

To give an impression of what is possible with just one Vosim function you can open the patches `VOSIM-Singer.pch2` and `VOSIM-Trance.pch2`. These two patches are based on control sequence data, which were also used in my other articles for controlling various synthesis models. Once again it clearly shows that the control of a synth model is of crucial importance for the final sounding result. And that also holds for Vosim.

A mix of Vosim functions
If we want to generate sounds with clearly multiple formants, we simply have to stack and mix multiple Vosim functions. An example of this can be found in the `VOSIM-WindIns.pch2` patch. Here two independent pulse trains are triggered by one and the same trigger oscillator to simulate wind instrument sounds, characterized by two formants.

VOSIMthePatch, how it works
In this image you see the simplified implementation of Kaegi's original Vosim model. The heart is formed by a trigger oscillator and a slave oscillator. The triger osc determines the pitch and the slave the formant frequencies.

For this it is necessary that the slave is synchronized by the trigger osc. The output of the slave is provided in an eneveloped generator module with an envelope with an decaying amplitude. This envelope generator is also triggered by the trigger oscillator.

The output of this evelope module can then be connected to a next envelope generator which, for example, is traditionally controlled by the keys on the synthesizer.

sine^2 pulses
The formation of the sine^2 wave pulses is as follows. The sine output is multiplied by itself in a multiplier module. The negative part of the sine is becoming positive by multiplying itself. Of course, the positive part remains positive.

We have obtained a new sine wave signal with double frequency and halved amplitude. Therefore, with a constant module, the slave oscillator is transposed an octave downwards. To bring the amplitude back to its original level, the output signal in an amp module is multiplied by two.

Bottom line
The most important Vosim parameters, the duration of the sine wave pulses and the number of pulses and their amplitude decrease are highly relevant to the perception.

Ernst Bonis

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