Chorus

VCarrara

Definition

Originally the Chorus effect aimed to add one or more replicas (wet) to the original signal (dry) to mimic orchestras or several identical instruments playing together. To be listening like instruments playing together, the copies must have changed several of their main characteristics, as, for instance, the frequency, amplitude, envelope, etc. In theory, a perfect Chorus should have an output given by

$$y(k) = x(k) + \sum_{i=1}^{n} x_i(k),$$

where $x(k)$ is the dry input and $x_i(k)$ are replicas (not really equals) of the dry signal. Real musical instruments show differences even when playing together synchronously. You may think how easy is to say if there is a single one or a whole orchestra of violins when you hear them playing. The resulting sound of a perfect chorus therefore should depend on the player, the action on the instrument, some small pitch and loudness variations, undetectable time delays, spectrum variations of the instruments, and also a large number of small but essential phenomena. Since the only available signal to a Chorus effect is a single instrument or voice input, an ideal Chorus therefore could be

$$y(k) = x(k) + \sum_{i=1}^{n} g_i[x(k), x(k-1), \cdots, x(k-m)],$$

for some large m and n. Even with such simplification the effort to define an effective function g_i is enormous. Further simplifications can be made by adopting functions that changes only few characteristics of the input signal, like introducing a time delay, pitch variations, volume (signal amplitude) and tone. When real time output with none or small latency is required, the output can be simplified to

$$y(k) = x(k) + x[k - o_{lfo}(k)],$$

where $o_{lfo}(k)$ is a delay provided by a Low Frequency Oscillator, so producing some delay together with pitch variation, whenever $o_{lfo}(k)$ changes, that is to say, $\mathrm{d}o_{lfo}/\mathrm{d}t \neq 0$. Usually o_{lfo} is based on sine oscillators.

Chorus

This simple model can be improved by adding more copies and amplitude variations, as, for instance

$$y(k) = x(k) + \sum_{i=1}^{n} v_i(k)\, x[k - o_i(k)],$$

with v_i also being provided by a Low Frequency Oscillator, that modulates the amplitude of each copy. The difference on quality of the single and multiple copies is noticeable, but still far from getting realistic perception of several instruments playing together. The v_i function modulates the wet signal by some amount while o_i produces some delay together with pitch variation. Of course $v_i(k)$ and $o_i(k)$ need to be continuous, which excludes envelopes like saw teeth or square waves. The delay must be short to be distinguished from echo, but greater than 5 ms to be noted as a time delay. A delay shorter than 5 ms can produce a flanging like effect, and can sound even like a Phaser. A more realistic Chorus shall include a pitch shifter in the wet signal to simulate multiple voices. However, the pitch shifter algorithm (for digital effects) requires large processing time and, therefore, rarely used in Chorus.

The chorus proposed here is a simple one, with a single delayed signal modulated by a LFO. In other words, the output is computed by

$$y(k) = x(k) + x[k - o(k)],$$

Some tests were performed with two or more delayed signals, but the improvement on the effect output was considered negligible and, therefore, disregarded. The modulation produced by $v(k)$ showed also meaningless changes. The block diagram in Z transform of the Chorus can be seen in Figure 1. In this figure, a stands for a fixed delay to forbid the delayed time to be too small when $o(k)$ is negative, since $a < n$ and $| o(k) | \leq 1$.

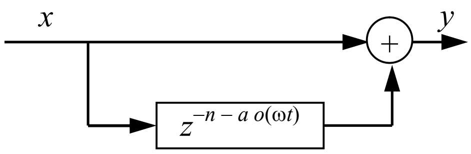

Fig 1 – Chorus block diagram.

More complex models of Chorus can be achieved by adding new oscillators, filters and modulating other parameters, such as amplitude and the modulation function. A good chorus effect algorithm can be found in the thesis of Gerard Amposta Boquera[1]. Even considering the large number of additions of oscillators and modulators to the Chorus mentioned in this work, the author emphasizes that “the algorithm was only superior to the cheapest chorus effects found on the market”. This shows that modeling a multi instrument effect using digital algorithms is still a tough and tricky task.

Table 1 shows some delay based effects and their dependencies on amplitude and pitch modulation, besides the number of delayed signals present in the wet output. Some effects, like Vibrato, for instance, depend exclusively on the wet signal. It can be seem in this table that Chorus and Vibrato are very similar. In fact, a Vibrato can be done with a Chorus effect provided the Dry signal is muted in the output, and the Wet part is pitch modulated (see Vibrato effect).

Table 1 – Effect composition and applied modulation

Effect	Dry		Wet		
	Output	Amplitude modulation	Number of delayed signals	Pitch modulation	Amplitude modulation
Chorus	✓		≥1	✓	✓
Vibrato	×		1	✓	×
Delay & Echo	✓	×	≥1	×	×
Reverber	✓	×	>>1	×	×
Flanger	✓	×	1	×	×
Tremolo	✓	✓	0	×	×

References

[1] Boquera, G. A. Implement a chorus effect in a real-time embedded system. Polytechnic University of Catalonia, Spain, 2016. Available at: <https://upcommons.upc.edu/bitstream/handle/2117/98219/pfc_doc.pdf?sequence=1&isAllowed=y>.