Music 320: Lab 3: Sound synthesis with FOFs.

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1 The singing voice

The human voice as a musical instrument combines a non-uniform acoustic tube resonator (the vocal tract) with a forced excitation mechanism (the vocal folds). A characteristic of voice is the formants, i.e. some peaks in the spectrum that arise from the resonances of the source.

The first formant will usually contribute more to timbre because of its greater amplitude and lower frequency, closer to the fundamental.

2 FOF synthesis

Ideas behind FOF synthesis:

- FOF stands for "Fonction d'onde formantique".
- Formant= peak of energy in the spectrum.
- Reconstruction of a sound by superposing the contributions of each formant.
- A FOF is a "grain" representing a fundamental period of a signal corresponding to a formant.
- Summing different FOFs together allows to obtain voice synthesis.
- It is a sinusoid multiplied by an exponential envelope.
- The parameters of a FOF (amplitude, frequency, decay) correspond to the parameters of a formant (amplitude, central frequency, bandwidth).

2.1 Fundamentals of FOFs

Formant wave function synthesis is the basic principle of CHANT. CHANT is a singing voice synthesizer which can be also used to model other resonators. The principle behind CHANT is subtractive synthesis, in which a source signal with a broad spectrum passes through a complicated filter.

These filters can be broken down in a set of parallel bandpass filters.

An alternative implementation replaces the filters with a bank of damped sine wave generators. This leads to the following time domain waveform:

$$s(n) = \begin{cases} 0, n \leq 0 \\ \frac{1}{2}(1-\cos(\beta n))e^{-\alpha n}\sin(\omega_c n + \phi), 0 \leq n \leq \pi/\beta \\ e^{-\alpha n}\sin(\omega_c n + \phi), n > \pi/\beta \end{cases} \quad (1)$$

where ω_c is the frequency of resonance, π/β = width of the skirts (in seconds) k is the sample index, α is the decay time. The formant skirt is defined as the lower part of the formant peak.

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3 The CHANT synthesizer

Each FOF provides a single formant. Combining FOFs together, as shown in figure 1, gives the CHANT synthesizer.

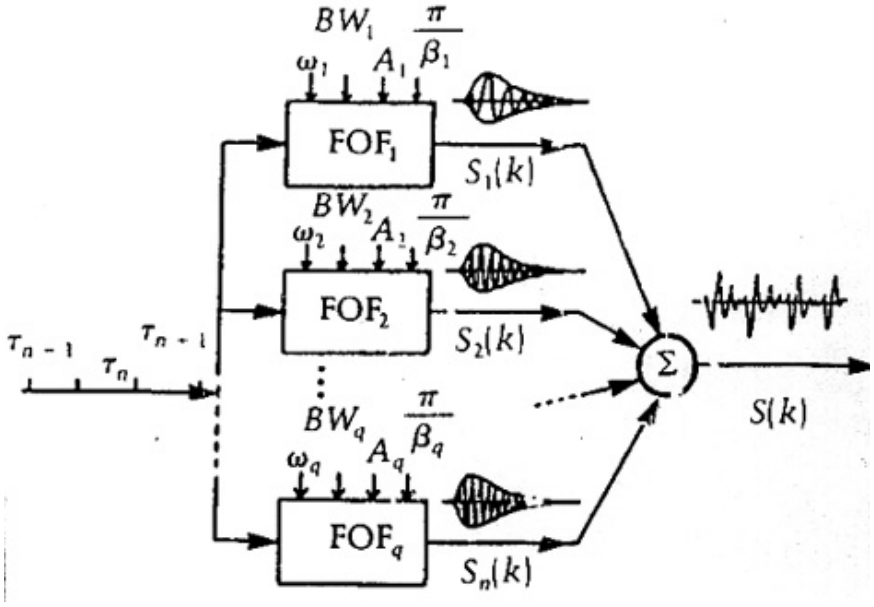

Figure 1: A FOF synthesizer as proposed in [Bennett and Rodet 1989].

- Application: demonstration of the CHANT synthesizer in MSP.

References

[Bennett and Rodet 1989] Bennett, G., and X. Rodet. 1989. "Synthesis of the Singing Voice.". *Pages 19–44 of:* Mathews, M. V., and J. R. Pierce (eds), *Current Directions in Computer Music Research.* Cambridge, MA: MIT Press.