

CHAPTER 4

The Synthesis of Sound by Computer

“By using digital oscillators instead of actual physical devices, a computer can add up any number of simple sounds to create extremely complex waveforms.”

– Burke et al., *Music and Computers*

Terms & Concepts

<p>4.1 Introduction to Sound Synthesis Direct synthesis Synthesis techniques Unpredictable information Noise: White, Pink, etc. Synthesis function</p> <p>4.2 Additive Synthesis Organ-stop analogy Telharmonium Superposition of sinusoids Spectral envelope - Common fate Sine wave speech Shepard tones - Circularity of pitch - Chroma</p> <p>4.3 Filters Filter types (Fig. 4.8) - Low pass - High pass - Band reject (notch) - Band pass - Comb Subtractive synthesis Cutoff frequency Transition band Pass band and stop band Bandwidth Center frequency Finite and infinite impulse response filter (FIRF & IIRF) Delays Averaging Feedback Unity gain transforms Digital signal processing</p>	<p>Filter theory One sample delay</p> <p>4.4 Formant Synthesis Formants (DFT) Resonant physical structure</p> <p>4.5 Amplitude Modulation Amplitude modulation (AM) Tremolo Low frequency oscillator (LFO) Signal block diagrams - Unit generator (ugen) - f - a - Waveshape Oscillator - Carrier - Modulator Two-operator AM</p> <p>4.6 Waveshaping Transfer function Chebyshev Polynomials - Order of the polynomial - Distortion index - Recursive formula Soft clipping Signal range - Bipolar: -1 to 1 - Unipolar: 0 to 1 Table-based waveshapes Algorithm - Optimization - Efficiency</p> <p>4.7 Frequency Modulation Frequency modulation (FM) - Carrier frequency (f_c) - Modulator frequency (f_m)</p>	<p>Vibrato FM index (f_c/f_m) Side bands Bessel functions</p> <p>4.8 Granular Synthesis Grain Grain envelope Clouds</p> <p>4.9 Physical Modeling Karplus-Strong algorithm - Buffer (filled with noise) - Delay - Feedback loop - Averaging Circular buffer Virtual instrument</p> <p>Composers & Inventors Don Buchla & Morton Subotnick Wendy Carlos & Robert Moog John Chowning Charles Dodge Ken Gaburo Paul Lansky Larry Polansky Jean-Claude Risset James Tenney Barry Truax Iannis Xenakis</p> <p>Software Cycling '74, Max/MSP Puckette, Pure Data (Pd) McCartney, SuperCollider 3 Vercoe, Csound</p>
--	--	--

Reference

Burk, Phil, Larry Polansky, Douglas Repetto, Mary Roberts and Dan Rockmore. 2011. *Music and Computers: A Theoretical and Historical Approach*, Archival Version. Available online at:
 <<http://music.columbia.edu/cmc/MusicAndComputers/>>.