ECE402 Lecture Topics
Electronic Music Survey Course – Haken and Cheng

Introduction to Lecture, Introduction to Lab, Choose Lab Teams and Times [Lect 1]

An Incomplete History of Electronic Music Technology since 1900 [Lect 2]
- Telharmonium, Theremin, Reproducing Piano, Ondes Martenot
- Trautonium, Hammond Organ, RCA Synthesizer [Lect 3, Quiz]
- Musique Concrète, Pierre Schaeffer, Classic Studio, Edgar Varèse
- Hugh LeCaine, Robert Moog, Don Buchla, Mellotron, Walter Carlos, Isao Tomita [Lect 4]
- Lejaren Hiller, Max Mathews, Iannis Xenakis
- Phase Oscillator and Wavetable Synthesis, FM [Lect 5]
- Samson Box, Dartmouth Synthesizer, Fairlight CMI, Yamaha DX7 [Lect 6]
- IMS Synthesizer, Platypus
- Midi, Midi Sequencers and Timbre Editors, Digital Control of Analog Synthesizers
- Software Synthesis, Physical Models, DSPs – CPUs – GPUs [Lect 7]

Music Encoding
- Kyma, Max, Reaktor
- Music Typesetting
- MusicXML
- Automated Music Transcription
- Optical Music Recognition (OMR)
- Braille Music [Lect 8]
- MusicN
- Midi Hardware Interface
- Midi Encoding, Running Mode, 14-bit Controller Fail, Control-Rate Aliasing [Lect 9]

Four Aspects of Music: Pitch, Loudness, Timing, Timbre
- Note Name, Pitch Class, Note Number, Cents, Frequency Ratios
- Equal Tempered Scale, Just Tuning, Perfect Triads, Commas [Lect 10]
- JND, Frequency, Accuracy Requirements for Phase Oscillator
- Equal Loudness, Sones, Phons, Total Loudness, Musical Dynamic Markings [Lect 11]
- Accelerando Formulae

Time-varying Spectral Analysis/Synthesis [Lect 12; Lect 13 Midterm]
- Pitch-tracking Analysis (Short Windows)
- McAulay-Quatieri Analysis (Long Windows) [Lect 14]
- Quadratic Phase Synthesis
- Noise Representation
- Phase Representation
- Time-Frequency Reassignment [Lect 15]

Psychoacoustics and Signal Processing
- Outer ear - Middle Ear - Inner Ear
- Shoulder, Head, and Pinna Effects
- Place Principle
- Otoacoustic Emissions
- Critical Band, Masking Pattern, Temporal Masking Effects [Lect 16]
- Barks
- Total Excitation Pattern

Fixed Waveform Synthesis
- No quasi-harmonic components
- Avoiding Aliasing
- Variable Duty-cycle Pulse Oscillator, Window Pulse Waveform
- Bandlimited Impulse Train, Bipolar BLIT, Leaky Integration [Lect 17]
- Phase Oscillator, Discrete Summation Formulae
- Engineer’s Sawtooth, Musician’s Sawtooth
Additive Synthesis with Complex Basis Functions [Lect 18]
Spectral Matching with Fixed Wavetables, Genetic Search
Properties of Group Additive Synthesis, Morphing Implementation

Sound Morphing and Cross Synthesis [Lect 19]
Additive Sound Morphing, Additive Cross Synthesis
Convolution
Talking Guitar Effect
Vocoder: Bandpass Filters, Amplitude Followers, Multipliers
LPC: Transfer Function, Number of Poles, Frame Rate, Stability, Error Function
Types of Inputs Useful for Vocoder and LPC

Pitch Processing [Lect 20]
Zero Crossings, Peak Detection
Comb Filter, 2nd Derivative
Autocorrelation
Cepstral Pitch Detection, Quefrency
Spectral Peak Labeling, String Inharmonicity Formula
How Not to Pitch Shift [Lect 21]
Pitch Shifting Using Lent’s Algorithm

Synchronous Granular Synthesis
Serialized Lent’s algorithm, Time Stretching and Pitch Shifting
Grain Spectra, Mixing, Morphing, Formant Preservation, Spectral Envelope Dilation

Asynchronous Granular Synthesis [Lect 22]
Sampled Grains, Granulated Sinusoids

IRCAM Chant Synthesis
Jenny Oscillator

Physical Models
Kinetic Model, Modeled Noise vs Filtered White Noise
Karplus-Strong (Simple Waveguide Model), Fractional Sample Delay (All Pass vs. Lagrange)
Models using Multiple Waveguides, Nonlinear Elements, Banded Waveguides, FDN [Lect 23]
Modal Synthesis, Nonlinear Feedback

Waveshaping (aka Nonlinear Filtering, or Memoryless Harmonic Distortion Synthesis) [Lect 24]
Clip, Soft Clip, etc.
Feedback Impedance Functions for Physical Models
Polynomial Table Function, Brightness and RMS Matching

Modulation Synthesis [Lect 25]
AM, RM, Single-sideband
FM, Spectral Frequencies and Amplitudes, FM Recipes
Multi-operator FM, Formant FM

Musician’s Filters [Lect 26]
Musician’s Low Pass Filter, Half-power Excursion, Transparency
Control Issues: Parameter Decoupling, Stability
All-pass Lattice, Regalia-Mitra Topology, Chamberlin Filter

AES3 Standard [Lect 27]
Biphase Encoding, Differential (Balanced) Signals
Block, Frame, Subframe, Time Slot, Channel Status

Lab Demos [Lect 28 & 29]