Music Signal Processing

Oberlin College ExCo
Fall 2018

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class meetings: 2 hours/week, time & location TBA

office hours: By appointment.

course overview: A theoretical and practical overview of how computers synthesize and process sound. Essentials of audio signal processing are explored as they relate to everyday music consumption. Other topics include musical acoustics, psychoacoustics, data compression, and source separation.

learning objectives:

Upon completion of this course, you will be able to:

- Explain musical terms with mathematical and scientific language
- Use technology to analyze and demonstrate acoustic principles
- Use technology to analyze and demonstrate digital signal processing techniques
- Understand the nature of the human hearing mechanism and psychoacoustics

course materials: If possible, students should bring a laptop and headphones to class. All other course materials will be provided.

prerequisites: Some background in mathematics, computer science, and/or music theory is preferred; However, there are no formal prerequisites for this course.

attendance policy: ExCo policy requires all students to attend 75% or more classes. Thus, in the 12-week period, you are allowed to miss a maximum of two classes; missing three or more classes without making them up will result in a No-Pass.

grading policy: This class will be graded Pass/No-Pass. Class participation will constitute 60% of your grade. The midterm project will constitute 15% of your final grade and the final project will constitute 25% of your final grade.

evaluations:

- Midterm: students will choose to complete either a 2 page paper or a 10 minute presentation where they select a piece of recorded music and both qualitatively and quantitatively analyze the effect that digital signal processing, musical acoustics, and psychoacoustics have on listening to that piece. Further information on the midterm project will be provided.

- Final: students will research a specific aspect of audio or music programming and complete either a 2 page paper or a 10 minute presentation about it and its ability or potential to impact the way we listen to music. Alternatively, different final project topics can be proposed individually by students. Further information on the final project will be provided.

tentative schedule:

Week 1: Fundamentals of sound and psychoacoustics, how digital audio works
Sound generation and propagation, wave mechanics, sound perception, sampling and quantizing sound waves

Week 2: Mathematical formalism of basic music theory
Pitch, rhythm, frequency, amplitude, harmony, scales, harmonics

Week 3: The Fourier transform
Discrete Fourier transforms, frequency domain, fast Fourier transforms, Nyquist theorem, aliasing, sound transformations

Week 4: Digital representations of music
DAC, ADC, MIDI, spectrograms, audiograms, musical notation

Week 5: Source separation
Cocktail party effect, blind signal separation, computational auditory scene analysis

Week 6: Audio data compression
Audio codecs, lossless vs. lossy, bandwidth, bitrate, audio compression algorithms

Week 7: Audio signal processing techniques, part 1
Additive synthesis, frequency/amplitude modulation, wavetable synthesis

Week 8: Audio signal processing techniques, part 2
Delay, flanging, chorusing, reverberation, panning, location, spatialization

Week 9: Engineering of microphone, headphone, and speaker design
Transduction, polar patterns, dynamic vs. condenser, dynamic loudspeaker, drivers, woofers, tweeters

Week 10: Psychoacoustic perception of sound
Sound localization, masking effects, Fletcher-Munson curves

Week 11: Acoustics of musical instruments
String instruments, percussion instruments, wind instruments

Week 12: Examining the effects of DSP on the commercial music industry
Spotify vs. Apple Music, digital copyrights, monetization of music streaming