Computational Sound

COMS 3430 - Fall 2021

Instructor Info

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Course Info —

Prereq: COMS 3157

Monday, Wednesday

75 min Lecture, 2x/week

516 Milstein

Capped at 24 students

Overview

In this course, we explore the variety of roles that computation can play in the analysis, creation, and performance of music. We start with the fundamentals of sound in the digital domain, covering issues of representation and audio synthesis. We then move through various synthesis techniques including the additive, subtractive, frequency modulation (FM), and amplitude modulation (AM) synthesis. After covering some core DSP techniques, we put these concepts into performative practice by exploring "live coding". In the space of live coding, we examine various programming language designs to understand how various domain specific languages (DSLs) support live coding. For the third module, we turn our focus to automated composition and analysis, addressing challenges in music information retrieval, generative art, and autonomous improvisation systems. All the while, we continue to develop our fluency in live coding by putting new topics to practice.

Grading Scheme

10%	Participation
60%	~6 Homeworks at ~10% each
30%	Final Project

Learning Outcomes

- Demonstrate familiarity with the foundations of digital representation and manipulation of sound
- Identify key open problems, and solution spaces, in the domain of computer music
- Ability to read and understand DSP code and systems
- Ability to connect musical concepts to mathematical structures to provide deeper in musical understanding
- Gain fluency in the practice of live coding

Material

Any required journal articles and book chapters will be provided on Courseworks.

Required Texts

Curtis Roads and John Strawn. The computer music tutorial. MIT press, 1996.

Andy Farnell. Designing Sound. MIT Press, 2010.

Recommended Text

Puckette, M. S. (2007). The theory and techniques of electronic music. Singapore, Singapore: World Scientific Publishing Company.

Late Policy

The late policy of this classes follows a policy found in many Barnard/Columbia CS courses. Each day (24-hour period) or partial day late incurs a 20% penalty on the assignment. However, you are allowed a total of 4 "flex" days, to be used as you wish throughout the semester (on written homeworks and/or projects). Late hours round up the nearest day. To use a "flex" day, simply submit your work late and add a note indicating how many "flex" days your late submission has incurred, and how many remaining "flex" days you have remaining. When possible, advance notice is appreciated.

If there is a situation that you feel should be exempt from this policy, you must reach out over email at least 48-hours prior to the due date of the assignment.

This policy does not apply to the final project, which cannot be accepted after the due date except in exceptional circumstances.

Class Attendance Policy

Beyond the 10% of your grade that is allocated to participation as stated above, you are expected to attend every class period. Excessive absences will require consultation.

FAQs

Will I learn how to be a DJ?/Will we make dope electronic beats?

No, this course will focus on the underlying computation issues of dealing with digital music.

Does that mean there is no creative aspect to this course?

Not at all! In fact, many assignments will require creativity not only from a technical perspective, but also from an artistic and musical perspective.

Do I need to have a strong background in music?

No, only an interest. You should be able to read music in Western notation, but we will not need more advanced topics you would know with a background in music.

What is computer music anyway?

It depends on who you ask. As we will see in this course, there is a wide range of interesting and valuable problems in the domain of audio for which computation plays an intergral role.

Honor Code

You are expected to hold yourself to the highest standard of academic integrity and honesty, as reflected in the Barnard Honor Code. Approved by the student body in 1912 and updated in 2016, the Code states:

We, the students of Barnard College, resolve to uphold the honor of the College by engaging with integrity in all of our academic pursuits. We affirm that academic integrity is the honorable creation and presentation of our own work. We acknowledge that it is our responsibility to seek clarification of proper forms of collaboration and use of academic resources in all assignments or exams. We consider academic integrity to include the proper use and care for all print, electronic, or other academic resources. We will respect the rights of others to engage in pursuit of learning in order to uphold our commitment to honor. We pledge to do all that is in our power to create a spirit of honesty and honor for its own sake.

Wellness Statement

It is important for undergraduates to recognize and identify the different pressures, burdens, and stressors you may be facing, whether personal, emotional, physical, financial, mental, or academic. We as a community urge you to make yourself–your own health, sanity, and wellness–your priority throughout this term and your career here. Sleep, exercise, and eating well can all be a part of a healthy regimen to cope with stress. Resources exist to support you in several sectors of your life, and we encourage you to make use of them. Should you have any questions about navigating these resources, please visit these sites:

- `http://barnard.edu/primarycare`
- `https://barnard.edu/about-counseling`
- `http://barnard.edu/wellwoman/about`
- Stressbusters Support Network

Center for Accessibility Resources & Disability Services

If you believe you may encounter barriers to the academic environment due to a documented disability or emerging health challenges, please feel free to contact me and/or the Center for Accessibility Resources & Disability Services (CARDS). Any student with approved academic accommodations is encouraged to contact me during office hours or via email. If you have questions regarding registering a disability or receiving accommodations for the semester, please contact CARDS at (212) 854-4634, cards@barnard.edu, or learn more at `barnard.edu/disabilityservices`. CARDS is located in 101 Altschul Hall.

Affordable Access to Course Texts & Materials

All students deserve to be able to study and make use of course texts and materials regardless of cost. Barnard librarians have partnered with students, faculty, and staff to find ways to increase student access to textbooks. By the first day of advance registration for each term, faculty will have provided information about required texts for each course on CourseWorks (including ISBN or author, title, publisher, copyright date, and price), which can be viewed by students. A number of cost-free or low-cost methods for accessing some types of courses texts are detailed on the Barnard Library Textbook Affordability guide (library.barnard.edu/textbook-affordability). Undergraduate students who identify as first-generation and/or low-income students may check out items from the FLIP lending libraries in the Barnard Library (library.barnard.edu/flip) and in Butler Library for an entire semester. Students may also consult with their professors, the Dean of Studies, and the Financial Aid Office about additional affordable alternatives for having access to course texts. Visit the guide and talk to your professors and your librarian for more details.

Class Schedule

Date	In-class topics	TODOs before class
MODULE 1: Digital Signal Processing for Audio (Wk 1-3)		
Sept 8	Computer Music as a Field 👥 Puckette, *Four Surprises* (in-class reading)	
Sept 13*	Basics of Digital Audio ADSR, LFOs ✎ Building a keyboard	Farnell, Ch. 7.1, 7.2 (9 pages) Roads, Ch. 1 (47 pages) ✎ Homework 0: Play a sound
Sept 15	Psychoacoustics 👥 Wegel and Lan, 1924: Demo 👥 Fletcher-Muson Experiment	Cook, Ch. 6 (10 pages) Roads, Ch. 23 (17 pages)
Sept 20	Additive Synthesis and Bells Modulation (AM/FM) Synthesis	Roads, Ch. 3 (30 pages) Roads, Ch. 4 (42 pages) ✎ Lab 1 (Build a keyboard) due
Sept 22*	✎ Build your own synth	Farnell, Part IV
Sept 27	Filters	Roads, Ch. 10, Farnell, Ch 16.7 ✎ Lab 2 (Build a synth) due
Sept 29	Comb, Allpass, and Spatialization 👥 Z-plane estimation Experiment	
Oct 4*	Physical Modelling ✎ Farnell Synthesis	
MODULE 2: Live Coding (Wk 4-5)		
Oct 6	Intro to Live Coding with SonicPi Ethos of Live Coding	✎ Lab 3 (Farnell Synthesis) due
Oct 11	Creative Systems Framework Pattern based Live Coding with Tidal	Wiggins, Geraint A., and Jamie Forth. "Computational Creativity and Live Algorithms." In *The Oxford Handbook of Algorithmic Music*.
Oct 13*	Language models for Live Coding ✎ Build your own Live Coding tool	
Oct 18	Live Coding visuals with Hydra	✎ Response to Lanksy, *A View from the Bus*, 1990

Oct 20	More Live Coding	

MODULE 3: Automated Analysis and Composition (Wk 6-9)

Oct 25	The role of automated composition	Roads, The Technology of Music, Ch. 21
	Markov models	Neirhaus, Algorithmic Composition: Paradigms of Automated Music Generation, Ch. 3
	Cellular automata	Neirhaus, Algorithmic Composition: Paradigms of Automated Music Generation, Ch. 8
	Ge Wang in-class Reading	Miranda, Cellular Automata Music: From Sound Synthesis to Musical Forms, in Evolutionary Computer Music, Ch. 8
		Lab 4 (Live Coding) due
Oct 27	12-tone composition	
	Pitch Set Theory	The Framework of Music Theory as Represented with Groups, Zhang, 2009
	Pitch Set Theory Generalized	
Nov 1	Neural Networks for automated composition with `magenta.js`	Magenta.js: A JavaScript API for Augmenting Creativity with Deep Learning, Roberts et al., 2018
Nov 3	OSC communication	
	Lab 5 (Automated Composition)	
Nov 8	More Automated Composition	
Nov 10	More Automated Composition	

MODULE 4: Audio Plugins (Wk 10-13)

Nov 15	Intro to Audio Plugins and JUCE	Pirkle, Designing Audio Plugins, Ch. 1
Nov 17	Multichannel/Ambisonics	(visit to CMC)
Nov 22	Multichannel/Ambisonics	(visit to CMC)
	Introduce final project	
Nov 24	No Class (School Holiday)	
Nov 29	Music Information Retrieval	(REMOTE?)
Dec 1	Music Recommender Systems	(REMOTE?)
Dec 6	FFT and Convolution	
	Machine Learning & Audio	DDSP: Differentiable Digital Signal Processing, Engel et. al, ICLR 2020
Dec 6	Career Fair day + Final Project time	
Dec 13	Audio Plugins	

Disclaimer

This syllabus (dates, the nature and number of projects, readings, topics, grading policy, etc) are subject to change either by necessity or design. Any changes will be reflected in a new syllabus and/or announced in class and on Canvas.