ECE-GY 6183: Digital Signal Processing Lab

ECE-UY 4163 Real-Time Digital Signal Processing

Electrical and Computer Engineering
Tandon School of Engineering, New York University

Fall 2020

This course is an introduction to the real-time implementation of digital signal processing (DSP) algorithms, with an emphasis on audio signal processing and audio effects.

The course will use Matlab and Python programming. Some Matlab experience is expected. No experience in Python required; the course will introduce Python as needed. This course can be taken independently of ECE 6113 and ECE 7133 (DSP I and DSP II).

Topics include: Audio input-output and buffering. Filtering (recursive and non-recursive filters, structures). Fast Fourier transform and windowed spectral analysis. Digital audio effects (delay line, amplitude modulation, reverberation, distortion, short-time Fourier transform). Students will learn to implement these algorithms for real-time audio processing in software.

Prerequisites

Discrete-Time Signal and Systems (undergraduate level is sufficient) (ECE 3054 or ECE 6113 or equivalent)
You should know: discrete-time convolution, Z-transform, transfer function, frequency response, difference equations, pole-zero diagrams, and the discrete-time Fourier transform.

Texts

You can read both books online through the NYU Library for free. You will need to login to the library.

1. *Audio Effects: Theory, Implementation and Application*
   Joshua D. Reiss, Andrew McPherson
   CRC Press, 2014
   NYU library: http://bobcat.library.nyu.edu/permalink/f/ci13eu/nyu_aleph005572860
   Publisher: http://www.crcpress.com/product/isbn/9781466560284

2. *DAFX – Digital Audio Effects*
   Udo Zölzer (editor)
   Wiley, 2002 (1st edition), 2011 (2nd edition)
   NYU library: http://bobcat.library.nyu.edu/permalink/f/1c17uag/nyu_aleph004863929
   Publisher: https://www.wiley.com/en-us/DAFX%3A+Digital+Audio+Effects%2C+2nd+Edition-p-9780470665992

Outline

1. DSP functions in Matlab
2. Graphical user interfaces (GUI) in Matlab
3. Finite impulse response (FIR) filters
4. Infinite impulse response (IIR) filters
5. Real-time spectral analysis
6. Python and PyAudio
7. Real-time input/output
8. Delay line audio effects
9. Filter design
10. Filter audio effects
11. Amplitude modulation audio effects
12. Graphical user interfaces (GUI) in Python
13. Real-time video processing in Python

14. Short-time Fourier transform

Project

Students will complete a real-time audio programming project and make a video presentation to be shared with the class.

Grading, Category weights (ECE 6183)

40%	Exercises
5%	Participation
25%	Midterm exam
10%	Paper (ECE 6183), DP2 proposal (ECE 4163)
20%	Project

In the event of academic dishonesty, a score of zero may be given for the item at issue. Additionally, the grade for the course may be reduced, including a failing grade for the course.

Software

Matlab: http://www.mathworks.com
Matlab at NYU: https://www.nyu.edu/life/information-technology/getting-started/software/matlab.html
Python : http://www.python.org
PyAudio : http://people.csail.mit.edu/hubert/pyaudio/

Instructor

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Learning objectives

1. The implementation and design of algorithms for signal processing with an emphasis on audio processing.
2. Software-based real-time programming of signal processing functions (real-time filtering, time-varying filtering, spectral analysis, audio effects).

Learning outcomes

1. Students will be able to use Matlab and Python to perform signal processing functions (filtering, spectral analysis, filter design).
2. Students will understand constraints and parameters associated with real-time signal processing (sampling rate, latency, buffering, bits per sample).
3. Students will be able to write programs to perform audio effects (reverberation, delay line effects, amplitude modulation, distortion).

Moses Center Statement of Disability

If you are student with a disability who is requesting accommodations, please contact New York University's Moses Center for Students with Disabilities (CSD) at 212-998-4980 or mosescsd@nyu.edu. You must be registered with CSD to receive accommodations. Information about the Moses Center can be found at http://www.nyu.edu/csd. The Moses Center is located at 726 Broadway on the 3rd floor.

NYU School of Engineering Policies and Procedures on Academic Misconduct

Introduction: The School of Engineering encourages academic excellence in an environment that promotes honesty, integrity, and fairness, and students at the School of Engineering are expected to exhibit those qualities in their academic work. It is through the process of submitting their own work and receiving honest feedback on that work that students may progress academically. Any act of academic dishonesty is seen as an attack upon the School and will not be tolerated. Furthermore, those who breach the School's rules on academic integrity will be sanctioned under this Policy. Students are responsible for familiarizing themselves with the School's Policy on Academic Misconduct.

Definition: Academic dishonesty may include misrepresentation, deception, dishonesty, or any act of falsification committed by a student to influence a grade or other academic evaluation. Academic dishonesty also includes intentionally damaging the academic work of others or assisting other students in acts of dishonesty. Common examples of academically dishonest behavior include, but are not limited to, the following:

1. Cheating: intentionally using or attempting to use unauthorized notes, books, electronic media, or electronic communications in an exam; talking with fellow students or looking at another person's work during an exam; submitting work prepared in advance for an in-class examination; having someone take an exam for you or taking an exam for someone else; violating other rules governing the administration of examinations.
2. Fabrication: including but not limited to, falsifying experimental data and/or citations.
3. Plagiarism: intentionally or knowingly representing the words or ideas of another as one's own in any academic exercise; failure to attribute direct quotations, paraphrases, or borrowed facts or information.
4. Unauthorized collaboration: working together on work that was meant to be done individually.
5. Duplicating work: presenting for grading the same work for more than one project or in more than one class, unless express and prior permission has been received from the course instructor(s) or research adviser involved.
6. Forgery: altering any academic document, including, but not limited to, academic records, admissions materials, or medical excuses.