ECE 7776: Advanced Digital Signal Processing

Syllabus – Fall 2018 – READ BEFORE DAY 1 OF LECTURE

**Summary:** This course surveys recent advances in signal processing concepts, especially those related to the acquisition, formation, processing, analysis, and visualization of images, videos, and similar multidimensional signals. This course begins by reviewing representations and applications of digital signals and images, including common tasks involving such signals. Successive lectures will feature discussions of recent research papers in these areas, and activities applying and reproducing their results. These lectures will connect these concepts to applications in biomedical imaging, computational photography, image and video compression, and other areas. Graded activities will include reviewing and critiquing papers, a midterm exam, and a semester-long research project.

**Instructor:** Daniel Weller
Assistant Professor, ECE
Rice Hall, Room 309
Email: dweller@virginia.edu (please put “ECE 7776” in the subject)
Phone: 434-924-4271 (x4-4271 from UVA phone)

**Location:** Tuesdays, Thursdays
12:30 – 1:45 PM
Mechanical Engineering 305

**Office Hours:** Tuesdays, Thursdays
2:00 – 3:00 PM
Rice Hall 309

**Textbook:** No textbook is required. In addition to assigned readings from papers and review articles, related reference texts include:

Learning Objectives: This course aims to provide the tools to use signal and image processing in research. By the conclusion of this course, students should be familiar with recent advances in signal and image processing, be able to understand and critique published work, and be confident in conducting and communicating research involving signal processing.

Lectures/Discussion: In addition to short in-class exercises, quizzes, and other activities, lectures frequently will discuss assigned readings of papers and review articles. It is essential to have read these papers in advance of class in order to fully benefit and contribute to these discussions. Students will be required to submit brief written reviews of these papers for a grade. Each review must include one question/discussion point that the student may raise in the class discussion. These reviews should relate the paper contents to material covered in the lectures, thus serving as homework for the course.

Midterm: The midterm exam will be given in-class and will cover concepts from the preceding lectures and readings. Exam questions will range from exercises like those during lectures to ideas discussed from the assigned readings.

Project: This course features a semester-long individual research project. This project should focus on an area of signal and image processing and involve original research (reproducing published work is not sufficient). Students will submit a written proposal describing the research idea and providing a preliminary survey of the relevant literature. Brief progress updates throughout the semester and a final report will comprise the remainder of the project grade.

Final Exam Presentations: In lieu of an exam, each student will present a brief talk describing their research project during the assigned final exam period. The final presentations will be conducted during the last week of class (December 4 and/or December 6).

Grading: Discussions/reviews (35%), midterm (15%), project (40%), and presentation (10%)

Prerequisites: ECE 6750 or instructor permission

Policies: All students are expected to abide by the UVA honor code policy. Late assignments generally will not be accepted; extensions must be approved by the instructor in advance of the due date. If there is a conflict for a scheduled final presentation, it is the student’s responsibility to notify the instructor before SEAS drop/withdraw deadline (October 23) to reschedule. Travel, holidays, or other commitments do not exempt students from this requirement. If you have concerns about course policies, about accessibility, or other issues, please contact the instructor as early as possible.
*Tentative* Schedule

08/28  Lecture 1
     Topic: Introduction to course; review of signals and systems; discussion of imaging and other applications

08/30  Lecture 2
     Topic: Sampling theory; how cameras work

09/04  Lecture 3
     Topic: Acquiring images with microscopes

09/06  Lecture 4
     Topic: Sampling magnetic moments with MRI

09/11  Lecture 5
     Topic: Sampling beyond Shannon

09/13  Lecture 6
     Topic: Compressive sensing and reconstruction

09/18  Lecture 7
     Topic: The single-pixel camera and CS-MRI

09/20  Lecture 8
     Topic: Computed tomography, filtered backprojection, and the ML-EM algorithm

09/25  Lecture 9
     Topic: Super-resolution microscopy

09/27  Lecture 10
     Topic: Data and image compression

10/02  Lecture 11
     Topic: Image enhancement: denoising

10/04  Lecture 12
     Topic: Image enhancement: deblurring and sharpening

10/09  NO CLASS (Reading Day)

10/11  Midterm Exam

10/16  Lecture 13 (Drop Deadline - SEAS)
     Topic: Image restoration and inpainting

10/18  Lecture 14
     Topic: Dictionary learning and other data-driven approaches

10/23, 10/25  Lectures 15-16 (10/23 is Withdraw Deadline – SEAS)
     Topic: Image segmentation
10/30, 11/01     Lecture 17-18
    Topic: Image classification
11/06, 11/08     Lecture 19-20
    Topic: Motion tracking
11/13, 11/15, 11/20 Lecture 21-23
    Topic: Machine learning for image analysis
11/22             NO CLASS (Thanksgiving)
11/27, 11/29     Lecture 24-25
    Topic: TBD
12/04, 12/06     Final presentations