ECE 5630 - Digital Signal and Image Processing

Syllabus - Fall 2016

Course Title: Digital Signal and Image Processing

Instructor: Dr. Scott E. Budge

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Office Hours:
T 9:00–11:00 am
R 9:00–11:00 am
Other hours by appointment.

Lecture Time: T R 3:00–4:15 pm

Lecture Place: EL 109

Prerequisite: ECE 3640 or equivalent

Textbooks:

1. Manolakis, G.D., Ingle, V.K., *Applied Digital Signal Processing*, Cambridge, New York, 2011.
2. Jain, Anil K., *Fundamentals of Digital Image Processing*, Prentice-Hall, New Jersey, 1989. (Available in Dept. library and on website.)

Reference:

1. Mitra, S.K., *Digital Signal Processing: A Computer-Based Approach*, Fourth Edition, McGraw–Hill, New York, 2011.
2. Oppenheim, A.V., Schafer, R.W., *Discrete-Time Signal Processing*, Third Edition, Prentice-Hall, New Jersey, 2010.
3. Proakis, J.G., Manolakis, D.G., *Digital Signal Processing Principles, Algorithms, and Applications*, Third Edition, Macmillan, New York, 1996.
4. Oppenheim, A.V., Schafer, R.W., *Digital Signal Processing*, Prentice-Hall, New Jersey, 1975.
5. Ifeachor, E.C., Jervis, B.W., *Digital Signal Processing: A Practical Approach*, Second Edition, Addison-Wesley, 2002.

TA: David Chester, davidchesterb@gmail.com, EL 258.

Cheating: Don't do it! The instructor reserves the right to fail any student who can be justifiably accused of cheating. The instructor recognizes that solution manuals are available for the homework, however, use of the solution manual for completing homework is considered cheating.

Final Exam Time: 1:30–3:20 pm on Thursday, December 15.

Course Accessibility: In cooperation with the Disability Resource Center, reasonable accommodation will be provided for qualified students with disabilities. Please meet with the instructor during the first week of class to make arrangements. Alternate format print materials (large print, audio, diskette or Braille) will be available through the Disability Resource Center.

Course Summary

The basic and principles of deterministic (nonstochastic) digital signal and image processing will be discussed. Initial topics include a review of Discrete-Time Signals and Systems, Z-transforms, the DFT, and sampling. As we review these concepts in 1D, we will then learn the corresponding topic (if applicable) in 2D (images). This will be followed by a selection of the topics:

1. IIR and FIR filter design techniques
2. Fast-Fourier Transform (FFT) algorithms
3. Fourier analysis
4. Cepstrum analysis and homomorphic deconvolution
5. Filter banks and multi-rate processing
6. Image perception and color processing

Lectures and homework problems will emphasize the theoretical concepts, while the programming assignments provide an opportunity for more practical understanding. Note that the practical aspects of DSP architectures and system implementation will be covered in ECE 5640 (taught Spring Semester).

Experience has shown that most students learn better when working in a team. This observation has been applied in industry, where most professional engineers are put in multidisciplinary teams to solve problems and develop new products. In this class, students are encouraged to work on the homework as teams outside of class.

Please be aware of the potential pitfalls when working with others to complete homework. It is easy, if you are undisciplined, to let others work homework for you. This will get your homework done, but in the long run you will have difficulty on tests and quizzes, and ultimately, you will not develop the skills for analytical thinking that employers will expect.

Course Outcomes

At the completion of the course, students will be able to do the following:

1. Demonstrate understanding of the extension of 1D digital signal processing concepts such as systems and signals, transforms, sampling and reconstruction into two dimensions (images).
2. Demonstrate understanding of the Discrete-time Fourier Transform (DTFT) and the Discrete Fourier Transform (DFT) and their uses in the analysis of discrete-time systems and signals.
3. Demonstrate ability to design both FIR and IIR digital filters.
4. Demonstrate understanding of common Fast Fourier Transform (FFT) algorithms.
5. Demonstrate understanding of multi-rate processing concepts such as band-pass sampling, decimation and interpolation for sample rate conversion and oversampling converters.
6. Demonstrate understanding of image perception, including color.

IDEA Course Evaluation

The standardized course evaluation system (IDEA) asks students to evaluate how well the course meets the stated objectives. The three IDEA essential or important objectives for this course are:

1. Learning to *apply* course material (to improve thinking, problem solving, and decisions).
2. Developing specific skills, competencies, and points of view needed by professionals in the field most closely related to this course.
3. Gaining factual knowledge (terminology, classifications, methods, trends).

You will be evaluating the course on how well the course helps you to meet these objectives. Please keep these in mind throughout the semester. These are the general objectives of the course, and the course outcomes stated above are specific to the topics in ECE 5630.

Philosophy

While a single course can not completely address a field as large as digital signal and image processing, the student will find himself prepared with the basic tools used in digital signal and image processing (DSIP). These tools will provide the student with the understanding necessary to approach new applications and literature. The student will understand the relationship between analog and digital processing, thereby having an intuitive feel for processes involved and opening the potential for creative new solutions to state-of-the-art problems. A through understanding of the transform methods used in digital signal analysis, processing, and system design will be developed.

DSIP is by its nature a very mathematical discipline. However, the mathematics are not outside of the reach of adequately prepared engineering students. As engineers, we must also go beyond the mathematics to a deep-seated understanding of what is implied about signals in the real world, and address issues such as implementation and feasibility. Some of this knowledge comes only by years of experience and practice. In this class, the mathematical principles will be emphasized with their relevance to engineering problems.

There are a number of areas in which the student of DSIP may apply himself, extending from very pure mathematical research to efficient implementation in VLSI. This class will take neither extreme, but will rather present mainstream ideas necessary for any serious work in DSIP.

Besides the mathematical aspects of DSIP, another very important skill is the ability to implement the ideas using digital computers. Pedagogically, one of the best ways to learn something yourself is to teach it to somebody else. Computers make wonderful "students" for this purpose: by the time you have "taught" the computer a particular algorithm, it is certain that you will have come to a deeper understanding of it yourself. Computers form an important tool in modern engineering; in DSIP work they provide the reason for the field. It is very important that you learn to program using correct principles and structure. In the modern field of DSIP, the ability to simulate algorithms is essential to the engineer.

In addition to programming in C or C++, it is beneficial to be able to use the computer to perform quick analysis. Many tools for analysis are available, such as Matlab.

Grading

Scores will be weighted as follows:

Midterm	25%
Homework	20%
Computer Assignments & Quizzes	30%
Final	25%
Total	100%

The grades will be based relative to the performance of the class as a whole. The starting point for grade adjustments is the Standard USU Grading Scale.

Homework

It is expected that students at the senior/graduate level understand the importance of homework. Therefore, homework will be assigned and the student will be required to complete the assignments promptly. The homework sets will be assigned and must be turned in three class periods (one week) after it is assigned. (There may be exceptions to this.) Do not wait until the last day to try the homework. **Please use the Departmental homework style illustrated on the website.** Homework will be accepted at 50% credit up to one week late.

Homework more than one week late will receive no credit unless a “Permission to Submit Homework Late for Extraordinary Reasons Form” (available on website) is submitted with the homework and the exception is given by the instructor.

It is department philosophy philosophy that students are responsible for their own learning. The instructor may not cover all of the material in each reading assignment in the lecture period. The student is therefore responsible for asking questions about reading material not covered in the lecture. Questions on exams and quizzes may come from lectures, labs, reading assignments, or supplementary materials given in class.

Course Outline

We will begin with a review of concepts studied in ECE 3640, primarily covered in chapters 1–7. As we review these concepts in 1D, we will then learn the corresponding topic (if applicable) in 2D (images) out of the Jain textbook. We will also be adding the topics in these chapters not covered in ECE 3640.

Once the basic concepts are completed, we will cover material in chapters 8, 10, 11, and 12 in the Manolakis text, and material in chapter 3 (and if time permits chapter 7) of the Jain text.

There is a large amount of information in the texts, so we will be skipping through the text and covering the most important parts. The interested student will want to read all of the material in the chapters, but it will not be required. Reading assignments will be given which cover the material the student is expected to understand.