Carnegie Mellon DSP-I Electrical & Computer ENGINEERING

Digital Signal Processing I (18-791)
Fall Semester, 2005

SYLLABUS FOR FALL 2005

Instructor: Professor Richard Stern, PH B30,(412) 268-2535, rms@cs.cmu.edu

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Teaching assistants: TBA

Overview of the course: This course covers the techniques of modern digital signal processing that are fundamental to a wide variety of application areas. We will review the mathematical basis of discrete-time signal analysis, discuss the theory and implementation of fast Fourier transform algorithms, and discuss the design and implementation of digital filters. We will complement our coverage of the fundamentals with introductory treatments of several advanced techniques including linear prediction, adaptive filtering, and two-dimensional signal processing. We will conclude the course with a discussion of the application of digital signal processing techniques toward the solution of various types of practical problems.

This course will make extensive use of MATLAB as an analysis, design, and visualization tool.

Grades will be based in part on performance in three examinations (nominally 67% of the final grade, with the final exam having the weight of 1.5 times the first two exams), and on homework assignments (nominally 33%, with the lowest homework grade dropped from the final grade computation).

Prerequisites: 18-396, or consent of the instructors. Seniors are encouraged to consider taking this course. Nevertheless, we note that this course is taught as a graduate-level course rather than as a senior-level course. Students are expected to work at a greater level of intensity than in undergraduate courses.

Class hours: Tuesdays and Thursdays, 9:30 to 11:20, HH B131. Recitations will meet Fridays from 2:30 to 3:20, also in HH B131.

Course textbook: We will use the Second Edition of the text *Discrete-Time Signal Processing* by A. V. Oppenheim and R. W. Schafer, with J. R. Buck (Prentice-Hall, 1998) as the primary text for the course. This book is a somewhat revised version of the original 1989 text by the same name, which in turn is a greatly expanded version of the classic text *Digital Signal Processing* published in 1975 by the same primary authors. Both editions of *Discrete-Time Signal Processing* are more verbose and tutorial than *Digital Signal Processing*, and they also include some new material that represents developments in signal processing that have taken place since the earlier text was published more than twenty years ago.

Some of the lab exercises will be drawn from *Digital Signal Processing Using* MATLAB by V. K. Ingle and J. G. Proakis (Brooks/Cole, 2000). This text is optional, but it is recommended as being useful in providing a complementary and far more applied perspective compared to Oppenheim, Schafer, and Buck, particularly in the area of digital filter design.

We have found that students benefit highly from having individual access to MATLAB. A site-licensed version of MATLAB can be obtained from Tech Electronics, but students are strongly encouraged to consider purchasing the Student Edition of MATLAB at the CMU Bookstore or directly from the Mathworks at

`http://www.mathworks.com`.

Other texts: There is a huge number of good textbooks on the subject of digital signal processing now on the market. *Digital Signal Processing: Principles, Algorithms and Applications* by J. G. Proakis and D. G. Manolakis (Third edition, Prentice-Hall, 1995) is a text that includes a number of additional topics but that is written in a style that is similar to that of Oppenheim and Schafer.

There are also several new texts that are integrating MATLAB into the presentation more than Oppenheim and Schafer. One such example is the text *Digital Signal Processing, A Computer-Based Approach* by S. K. Mitra (Second edition, McGraw-Hill, 2001), which has a bit more of an applied flavor than Oppenheim and Schafer.

Homework: Problem sets will be assigned every one to two weeks, to be turned in at the beginning of the class when they are due.

Computer assignments: A component of the homework will be computer assignments using the MATLAB. analysis package. You will be given accounts on the educational computers of the ECE department if you need them, but you are also encouraged to run MATLAB on your own personal computer and/or workstation if you have one.

Examinations: The first two exams will be held during the normal class meeting times on October 20 and November 17. The final examination will be scheduled by the Registrar during the final exam period, which runs from December. 12 through December 20. Please do not make any holiday travel commitments before December 20!

Please arrange your other commitments so as not to conflict with these dates. Make-up exams will not be given without extremely compelling reasons.

18-791 home page: We are maintaining a home page for 18-791 which may be accessed through the URL

`http://www.ece.cmu.edu/~ee791/`

We will be putting all course handouts, reference documents, and other information on the 18-791 home page. The pages will also include the MATLAB scripts used for classroom demos and other material presented in the lectures.

We will also make limited use of the Blackboard courseware that is being used by many other courses in the ECE Department, primarily for processing and distributing grades. We will also set up email distribution lists that students can use to discuss course issues, ask general questions, gripe about the course, etc.

Office hours: TBA

TOPIC OUTLINE FOR 18-791

Characterization of DT signals and systems

- Signal representation and convolution
- Discrete-time Fourier transforms and *Z*-transforms
- Discrete Fourier transforms and circular convolution
- Fast Fourier transform (FFT) algorithms

Digital filter design and implementation

- FIR and IIR filter structures
- IIR designs from prototype analog filters
- FIR designs using windowing and frequency sampling
- Computer-aided optimal filter design
- Filter design using least-squares modeling techniques
- Lattice filters and their implementation

Additional topics (not all will be covered)

- Adaptive filters
- Homomorphic filtering and the complex cepstrum
- Applications to speech and image processing

TENTATIVE COURSE OUTLINE

Note: This information is provided only to give you a rough idea of how the course material will be presented, and most likely presents an overly optimistic timetable. All specific details are subject to change.

No. and Date		Lecture Topic, Sections in Oppenheim, Schafer, and Buck
1.	**8/30**	Intro to course, review of continuous-time signal and system concepts (1)
2.	**9/1**	Review of discrete-time signals and systems; convolution (2.0 - 2.4)
3.	**9/6**	Difference equations and discrete-time Fourier transforms (2.5 - 2.9)
4.	**9/8**	DTFTs & CTFTs of periodic and sampled signals (4.0 - 4.5)
5.	**9/13**	Introduction to multi-rate DSP: decimation & interpolation (4.6)
6.	**9/15**	Implementation of decimation & interpolation; Intro to Z-transforms (4.6; 3.0-3.3)
7.	**9/20**	Z-transform properties and inverses (3.2 - 3.4)
8.	**9/22**	Z-transforms and frequency response of LSI systems (5.0 - 5.8)
9.	**9/27**	Intro to discrete Fourier series and the discrete Fourier transform (8.0 - 8.5)
10.	**9/29**	The DFT and circular convolution (8.5 - 8.7)
11.	**10/4**	Intro to fast Fourier transform algorithms (9.0 - 9.1, 9.3)
12.	**10/6**	FFT structures, algorithms, and computational considerations (9.3 - 9.6)
13.	**10/11**	Intro to digital filter implementation (6.0 - 6.3)
14.	**10/13**	IIR filter structures and implementation (6.3 - 6.5)
15.	**10/18**	FIR structures and implementation (6.5 - 6.7)
16.	**10/20**	**QUIZ 1**
17.	**10/25**	IIR filter design; use of analog prototypes (7.0 - 7.1)
18.	**10/27**	IIR design examples (7.1)
19.	**11/1**	FIR design using windows (7.2 - 7.3)
20.	**11/3**	Computer-aided FIR design: The Parks-McClellan algorithm (7.4 - 7.5)
21.	**11/8**	Intro to linear prediction (notes)
22.	**11/10**	Linear prediction and lattice filters (notes)
23.	**11/15**	Intro to adaptive filters (notes)
24.	**11/17**	**QUIZ 2**
25.	**11/22**	Intro to two-dimensional signal processing (notes)
26.	**11/24**	**THANKSGIVING HOLIDAY** (no class)
27.	**11/29**	Two-dimensional filter design (notes)
28.	**12/1**	Short-time Fourier analysis and spectrograms (10.0 - 10.5)
29.	**12/6**	Applications to speech processing (notes)
30.	**12/8**	TBA