San José State University College of Engineering,
Electrical Engineering Department,
EE254, Digital Signal Processing II, Spring 2011

Instructor:	Prof. Essam Marouf
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Office Hours:	M&W 2:15-4:15 pm
Class Days/Time:	M&W 6:00-7:15 pm
Classroom:	IS 113 (may change)
Prerequisites:	Familiarity with digital filters, matrix algebra, and random signal analysis; EE253, EE250, or equivalent

EE254 Website

There will be a website for this course hosted by SJSU D2L (Desire-2-Learn), accessible through your account on http://sjsu.desire2learn.com. More detailed instructions will be provided in class. All handouts will be posted there (except for the Lecture Notes; available as a course reader at the university bookstore). Only officially registered students can access the website.

Course Objectives

After a brief review of basic results achieved in the DSP I course (EE253), the course proceeds to develop analytical and computational tools to study:

1- Decimation, interpolation and sample rate conversion. Efficient cascade and polyphase implementations.
2- Perfect reconstruction 2-channel filter banks. Quadrature-mirror, power-symmetric, and approximate implementations. Simple orthogonal and biorthogonal filter banks.
3- Binary tree-structured perfect-reconstruction filter banks. The discrete wavelet transform (DWT). Application to image compression and signal denoising.
4- Time and frequency domain characterization of random signals. Correlation and power-spectra of filtered white noise random signal models (AR, MA, and ARMA models). Whitening filters. Vector random signal models, correlation matrix, eigenvectors and eigenvalues properties.
5- Estimation of mean and autocorrelation function from random signal realizations.
6- Classical (non-parametric) & model-based (parametric) power spectrum estimation.

7- FIR & IIR Optimal (Wiener) filtering. Optimal system function and corresponding mean-square error. Application signal denoising and interference cancellation.
8- Forward and backward linear predictors as Weiner filters. The Levinson-Durbin algorithm and the lattice error-filters realization. Application to speech coding. The Burg algorithm for estimating the lattice filter coefficients. Lattice-ladder realization of the Wiener filter.
9- Adaptive implementation of Wiener filters. Geometry of the mean-square error surface. The steepest descent algorithm for searching the error surface. Conversion conditions, the learning curve, and speed of convergence.
10- The LMS adaptive algorithm and its close relatives. Performance measures (speed of convergence and the excess mean-square error). The basic RLS algorithm and comparison with the LMS algorithm.
11- Application to adaptive interference/noise cancellation, adaptive system identification, adaptive line enhancement, adaptive channel equalization, … .
12- Adaptive implementation of the linear-prediction error filters and general Wiener filters using the gradient adaptive lattice (GAL) implementation.

Required & Recommended Texts/Software

Textbook

1- Statistical Digital Signal Processing and Modeling, M. Hayes, Wiley,1996. **Required**.
2- Class Lecture Notes (available at reproduction cost at the bookstore). **Required**.
3- The Student Version of Matlab and the Signal Processing Toolbox (included in the Student Version Release 2007a or later), the Mathworks. **Recommended**.

Other References

1- Statistical and Adaptive Signal Processing, Manolakis, Ingle, and Kogon, McGraw-Hill, 2000
2- Adaptive Filter Theory, 4th Ed., S. Haykin, Prentice-Hall, 2001.
3- Adaptive Filtering: Algorithms and Practical Implementation, 3nd Ed., P. Diniz, Springer, 2008.
4- Adaptive Signal Processing, Widrow and Stearns, Prentice-Hall, 1985.
5- Adaptive Filters:Theory and Applications, B. Farhang-Boroujeny, Wiley, 1998.
6- Optimal and Adaptive Signal Processing, P. Clarkson, CRC, 1993.
7- A Course in Digital Signal Processing, B. Porat, Wiley, 1997.
8- Digital Signal Processing, 4rd Edition, J. Proakis and D. Manolakis. Prentice-Hall, 2007.

Software: Matlab & the Signal Processing Toolbox

Matlab is used as the computational platform for class examples and homework problems. Matlab and many of its Toolboxes are available on the PCs in room ENG 387. The lab operates on an open door policy. Check availability times posted on the lab door. You may also consider purchasing the Student Version of Matlab (~$100) for private use at school and home. This is perhaps the most time flexible way to do the computational assignments and Project. The Student Version Release R2007a and after include the Signal Processing Toolbox. Check the web site http://www.mathworks.com/academia/ for more information. You may order the Matlab Student Version on the web or may purchase it directly from the Spartan Bookstore, Textbooks Department.

The Matlab m-files referenced in all textbooks can be downloaded from the websites below:
1) Hayes: http://users.ece.gatech.edu/~mhayes/stat_dsp/.
2) Mitra 3rd Ed.: http://www.mhhe.com/mitra/ (only Chs. 13 &14 are required)

If you are not familiar with Matlab (you should be if you already took EE253), you should go through the tutorials in the Student Version manual immediately! A web- based introduction is at http://www.mathworks.com/access/helpdesk/help/techdoc/matlab.shtml. Electonic versions of all Matlab+Toolboxes manuals may be accessed at the same web site. Matlab has a good help facility that you should invoke to learn more about specific commands or functions.

Dropping and Adding

Students are responsible for understanding the policies and procedures about add/drops, academic renewal, etc. Information on add/drops are available at http://info.sjsu.edu/web-dbgen/narr/soc-fall/rec-298.html. Information about late drop is available at http://www.sjsu.edu/sac/advising/latedrops/policy/ **.** Students should be aware of the current deadlines and penalties for adding and dropping classes.

Assignments and Grading Policy

Grading:	Homework	5%
	Midterm Exam #1 (Monday 03/07/11)	30%
	Midterm Exam #2 (Wednesday 04/20/11)	30%
	Optional Term Project (replaces the worst midterm)	30%
	Final Exam (Monday 5/23/11, 5:15-7:30 pm)	35%

Exams & Term Project:

All exams are in-class. Two 8.5"x11" double-sided summary sheets are allowed. No other course material is allowed. No make up exams are given. A term project that deals with an in depth study of a relevant application, including computer simulations using Matlab or DSP hardware implementation, is optional. The project grade replaces the worst of the two midterms. More details regarding topics and the scope of the term project will be handed out in class at a later time.

Homework:

Homework is crucial for the understanding of the course material. Homework will be assigned regularly. Part will be fully graded and the other part will be checked for completeness. Solutions for the analytical part of the problems will be provided. Part of the homework will require using Matlab. Please note that the 5% for the homework can move your grade across grade boundaries.

University Policies

Academic integrity

Students should know that the University's Academic Integrity Policy is availabe at http://www.sa.sjsu.edu/download/judicial_affairs/Academic_Integrity_Policy_S07-2.pdf.

Your own commitment to learning, as evidenced by your enrollment at San Jose State University and the University's integrity policy, require you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The website for Student Conduct and Ethical Development is available at http://www.sa.sjsu.edu/judicial_affairs/index.html.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism (presenting the work of another as your own, or the use of another person's ideas without giving proper credit) will result in a failing grade and sanctions by the University. For this class, all assignments are to be completed by the individual student unless otherwise specified. If you would like to include in your assignment any material you have submitted, or plan to submit for another class, please note that SJSU's Academic Policy F06-1 requires approval of instructors.

EE Department Honor Code

The Electrical Engineering Department will enforce the following Honor Code that must be read and accepted by all students.

"I have read the Honor Code and agree with its provisions. My continued enrollment in this course constitutes full acceptance of this code. I will NOT:

- Take an exam in place of someone else, or have someone take an exam in my place
- Give information or receive information from another person during an exam
- Use more reference material during an exam than is allowed by the instructor
- Obtain a copy of an exam prior to the time it is given
- Alter an exam after it has been graded and then return it to the instructor for re-grading
- Leave the exam room without returning the exam to the instructor."

Measures Dealing with Occurrences of Cheating

- Department policy mandates that the student or students involved in cheating will receive an "F" on that evaluation instrument (paper, exam, project, homework, etc.) and will be reported to the Department and the University.
- A student's second offense in any course will result in a Department recommendation of suspension from the University.

IMPORTANT NOTE: POSSIBLE FRIDAY LECTURES

In addition to my teaching duties, I am also involved in research projects related to planetary exploration by unmanned spacecraft. To be able to attend related technical meetings during the semester, some rescheduling of class time will be necessary. During one or more weeks of the semester the class may be taught M & F, W & F, or M, W, & F to compensate for any sessions missed during travel. Please make sure that you are available to attend the lecture on Friday (6:00-7:15 pm), in addition to the regular times on M & W. Any Friday lectures will be announced in class ahead of time.

TENTATIVE TOPICS COVERED & READING ASSIGNMENTS

Please read Hayes Sec. 2.2 to review some basic DSP material (covered in EE253), and Hayes Sec. 2.3 to review important linear algebra concepts.

MULTIRATE SIGNAL PROCESSING

	Mitra 3rd Ed (Handout)
Decimation and interpolation; sample rate conversion	13.1-13.3
Polyphase decomposition	13.4-13.5
Filter banks	13.6, 14.1, 14.2
Perfect-reconstruction (PR) two-channel filter banks	14.3
Tree-structured, multi-channel, PR filter banks	14.5-14.6
Selected Applications	

CHATACTERIZATION OF NOISY SIGNALS & SPECTRUM ESTIMATION

	Hayes
Correlation, power spectra, and filtering of noisy signals (review)	3.3-3.5
Filtered white-noise signal models (MA, AR, ARMA models)	3.6
Estimation of mean and correlation function	
Classical spectrum estimation (Bartlett, Welch, Blackman-Tukey, ...	8.2
Parametric spectrum estimation (AR, MA, ARMA)	8.4
Applications: Detection and parameter estimation of noisy sinusoids	8.2

OPTIMAL FILTERING, LINEAR PREDICTION, & LPC CODING OF SPEECH

	Hayes
Optimal (Wiener) FIR/IIR Filtering	7.2, 7.3
Applications: signal filtering, system identification, noise cancellation, channel equalization, linear prediction	7.2
Forward/Backward linear prediction	5.2.1-5.2.5
Levinson-Durbin Algorithm.	5.2.1-5.2.5
Lattice Realizations	6.2, 6.4, 7.2.4
Applications: LPC coding of speech; speech synthesis.	

FIR ADAPTIVE FILTERING

	Hayes
The mean-square error performance surface	9.1, 9.2
Steepest-descent search algorithm	9.2.1
Adaptive LMS algorithm	9.2
Performance measures	9.2.3
Variants of LMS Algorithm	9.2.6
Gradient Adaptive Lattice (GAL) algorithm	9.2.7, 9.2.8
Recursive Least-Square (RLS) algorithm	9.4
Applications: linear prediction echo cancellation, interference suppression, system modeling, line enhancement, channel equalization, …	9.2.5, 9.2.9

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Tentative Class Schedule (v1; will be updated as needed)

Week	Day	Lecture Notes	Homework out	Homework due
1	W 1/26 F 1/28	Intro, Lec 1		
2	M 1/31 W 2/2 F 2/4	Moved Lec 2a Lec 2b		
3	M 2/7 W 2/9 F 2/11	Lec 2c Lec 3 (pp. 1-3)	HW #1 out	
4	M 2/14 W 2/16 F 2/18	Lec 4a Lec 4b		
5	M 2/21 W 2/23 F 2/25	Lec 5 Lec 6a	HW #2 out	HW #1 due
6	M 2/28 W 3/2 F 3/4	Lec 6b Lec 7a	HW #3 out	HW #2 due
7	M 3/7 W 3/9 F 3/11	Midterm #1 Lec 7b		
8	M 3/14 W 3/16 F 3/18	Lec 8 Lec 9a		
9	M 3/21 W 3/23 F 3/25	Lec 9b Lec 9c	HW #4 out	HW #3 due
10	M 3/28 W 3/30 F 4/1	Spring Recess Spring Recess		
11	M 4/4 W 4/6 F 4/8	Lec 10a Lec 10b, Lec 11	HW #5 out	HW#4 due

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Tentative Class Schedule (v1)

Week	Day	Lecture Covered	HW out	HW due
12	M 4/11	Lec 12		
	W 4/13	Lec 13		
	F 4/15			
13	M 4/18	Lec 14	HW # 6 out	HW #5 due
	W 4/20	MT # 2		
	F 4/22			
14	M 4/25	Lec 15		
	W 4/27	Lec 16		
	F 4/29			
15	M 5/2	Lec 17		
	W 5/4	Lec 18	HW # 7 out	HW #6 due
	F 5/6			
16	M 5/9	Lec 19		
	W 5/11	Lec 20		
	F 5/13			
17	M 5/16	Lec 21		HW #7 due
	W 5/18	NO CLASSES		
	F 5/20			
	M 5/23	Final Exam		

Holidays; Campus is Closed
Midterm and Final Exams
Lectures that need to be moved
Makeup Friday lectures