Michigan State University

DEPARTMENT OF ELECTRICAL & COMPUTER ENGINEERING

ECE 966C: Statistical Signal Processing II: Adaptive Filtering and System Identification

Spring Semester, 2005

⟹COURSE WEB SITE https://angel.msu.edu ⟸

Prerequisites
- Background in stochastic processes (ECE 863) and in signal processing (ECE 466) (Background like that in ECE 864 (Det'n & Est'n) is desirable, but not mandatory.)
- Familiarity with some computing platform and the ability to use MATLAB on that platform.

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Office Hours TBA

Text Simon Haykin, *Adaptive Filter Theory* (4^{th} ed.), Prentice-Hall, 2002.

Reference Materials List posted on course web site

About the Course

Course Objectives. This course is an advanced graduate-level offering in the concentration area of Signal Processing (SP). The main objectives of this course are:

1. To provide a solid fundamental background for advanced research and development in many modern SP technologies involving adaptive filtering, estimation, and identification;
2. To provide the student who is seriously interested in signal processing, more exposure to, and experience with, fundamental signal processing concepts studied in earlier courses.
3. To provide knowledge of, and practical experience with, advanced tools (algorithms) which build upon earlier SP studies and which can be used to deploy the more elementary concepts in many important applications of SP.
4. To provide the graduate student with an appreciation for the nature of research.

Course Format. Principally lecture format, but with class discussions, problem discussions, and project / application discussions strongly encouraged.

Course Outline and Schedule & Assignment Chart. Included with this syllabus is an outline of topics to be covered, and a tentative schedule of coverage of those topics including correlative readings in Haykin. Updates to the topic outline and schedule will be posted on the course web site.

Homework. Homework assignments along with due dates will be posted (roughly bi-weekly) on the course web site. **Late homework will generally not be accepted.** Problems will be discussed in and outside of class to the extent that students have questions (*even prior to submission!*), and to the extent that certain problems might be particularly illustrative of important points. Solutions will be provided in some form (probably web postings).

Course Project. To be discussed in class, and information posted on class web site.

Examinations & Grading. In determining a final grade, assignments will be weighted as follows:

Written & computer homework	20%
Midterm examination	25%
Final examination	30%
Semester project & related	25%

The final course grade will be based on an evaluation of the percentage score and overall performance.

An INCOMPLETE (I) grade will be given only in unusual cases of illness or other personal emergency which causes the student to miss a significant amount of the course. The DEFERRED (DF) is reserved for special circumstances in which a student has undertaken special work which, in the instructor's opinion, would benefit from extra time beyond the semester period. The I and DF grades will NOT be given for any other reasons. University policy dictates that in order to be eligible for an I or DF grade, a student must be doing passing work at the time the grade is recorded. In the case of the I grade, the student must, in the instructor's opinion, be capable of completing the missed work with reasonable provisions.

ECE 966C - TOPIC OUTLINE WITH TENTATIVE SCHEDULE

UPDATE OF 01/07/05 – *Updates on class web page*

DATES	TOPIC(S)	READING (HAYKIN)	HW ASSIGNMENTS/ NOTES
	PART 1: BACKGROUND		
Wks of 1/10 & 1/17	INTRODUCTION TO THE COURSE	"Background and Preview"	
	BACKGROUND TOPICS IN STOCHASTIC PROCESSES, STOCHASTIC MODELS & EST'N THEORY	Ch. 1	
	Overview of key concepts - Will return as material requires		
	EIGENANALYSIS	Appendix E	
	Eigenvalues, Eigenvectors and properties		
	Computation of Eigenvalues		
	Eigenfilters		
	Subspace modeling		
Mon., 1/15/05	MLK Day Observance - No Classes		
	PART 2: OPTIMAL LINEAR FILTERING IN A STATIONARY STOCHASTIC SETTING		
Wk of 1/24	FIR WIENER FILTERS	Ch. 2, Appendices B&D	
	Wiener-Hopf equations		
	Principle of orthogonality		
	Problems and applications		
	Solving the Wiener-Hopf equations		
Wks of 1/31 & 2/7	LINEAR PREDICTION	Ch. 3	
	Forward and backward LP		
	Solution methods for the normal equations		
	Short-term LP solutions		
	Lattice implementations		
	Properties of prediction error filters		
	Schur-Cohn test		
	Autoregressive modeling of a stochastic process, & the inverse filter		
	Joint process estimation		
	Block estimation		
	PART 3: ADAPTIVE LINEAR FILTERING		
Wks of 2/14, 2/21 & 2/28	STOCHASTIC GRADIENT METHODS	Chs. 4,5,6 & 7 (partial)	
	Steepest descent		
	LMS algorithm		
	Performance analysis		
	Variations on the LMS algorithm		
	Application examples and comparison of techniques		
Wed., 3/2	**Midterm Exam**		
Wk of 3/7	Spring Break - No Classes		
Wks of 3/14, 3/21 3/28	LEAST SQUARE ERROR (LSE) METHODS AND RLS ALGORITHM		
	Classical batch LSE problem	Ch. 8	
	RLS algorithm	Ch. 9	
	QR-RLS and related algorithms	Appendix F, Section 12.9	

Wk of 4/4	SET-THEORETIC METHODS General theory OBE algorithms	Notes, paper
Wks of 4/11 & 4/18 (Mon)	TRACKING OF TIME-VARYING SIGNALS & SYSTEMS Generalities Performance of LMS, RLS, OBE Example applications	Ch. 14
4/20 (Wed) & 4/25 (Mon)	DISCRETE-TIME KALMAN FILTERS KF problem statement Innovations process State estimation using the innovations process Filtering Initial conditions KF variants Extended KF	Ch. 10, Notes by Prof. Wm. Powers
	PART 4: ADAPTIVE NONLINEAR FILTERING	
4/27	SELECTED TOPICS Blind deconvolution / equalization Volterra filters A mention of artifical neural networks	TBD
WEDS., 5/4/05 7:45-9:45 a.m.	**Final Exam**	