Department of Electrical and Computer Engineering
College of Engineering and Applied Sciences
Western Michigan University
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ECE 6950
Adaptive Filters and Systems

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Course/Lecture Overview

- Syllabus
- Personal Intro.
- Textbook/Materials Used
- Additional Reading
- ID and Acknowledgment of Policies

- Textbook
- Chapter1

Syllabus

- Everything useful for this class can be found on Dr. Bazuin's web site!
  - http://homepages.wmich.edu/~bazuinb/
- The class web site is at
  - http://homepages.wmich.edu/~bazuinb/ECE6950Adaptive/ECE6950_Fa11.htm
- The syllabus …
  - http://homepages.wmich.edu/~bazuinb/ECE6950Adaptive/Syl_6950Adapt.pdf

Who am I?

- Dr. Bradley J. Bazuin
  - Born and raised in Grand Rapids Michigan, Forest Hills School District
  - Education
    - BS in Engineering and Applied Sciences, Extensive Electrical Engineering from Yale University in 1980
    - Graduate MS and PhD in Electrical Engineering from Stanford University in 1982 and 1989, respectively.
  - Industry
    - Part-time ARGOSystems, Inc. (purchased by Boeing) 1981-1989
    - Full-time ARGOSystems, Inc. 1989-1991
    - Full-time Radix Technologies 1991-2000
  - Academia
    - Term-appointed Faculty, WMU ECE Dept. 2000-2001
    - Tenure track Assistant Professor, WMU ECE Dept. 2001-2007
    - Tenured Associate Professor, WMU ECE Dept. 2007-
  - Research
    - Wireless communications, RF signal physical layer signal processing
    - CAViDS condition based maintenance – sensors electronics and embedded microcontroller
    - Roll-to-roll Printed Electronics - organic and polymer semiconductors and functional materials used to form basic electronic devices and circuits
    - Sunseeker Electronics – CAN bus, CAN custom PCBs, battery protection system

Required Textbook/Materials

- Ali. H. Sayed, “Fundamentals of Adaptive Filtering,” Wiley & Sons, Hoboken, NJ, 2003, ISBN: 978-0-471-46126-5.

- MATLAB, Student Edition
- MATLAB Signal Processing Toolbox
  - The MATH Works,
    MATLAB and Signal Processing Toolbox
    http://www.mathworks.com/

Supplemental Books and Materials

- S. Haykin, Adaptive Filter Theory, 4th ed., Prentice-Hall, 2002.
- Ali. H. Sayed, “Adaptive Filters,” Wiley & Sons, Hoboken, NJ, 2008, ISBN: 978-0-470-25388-5.
- Ali. H. Sayed, “Adaptive Filters,” IEEE-Wiley eBooks Library Title, http://ieeexplore.ieee.org/xpl/bkabstractplus.jsp?bkn=5237520
- J.R. Treicher, C. R. Johnson, Jr., M.G. Larimore, “Theory and Design of Adaptive Filters”, Prentice-Hall, Upper Saddle River, NJ, 2001. ISBN: 0-13-040265-6.
- G.H. Golub and C.F. Van Loan, “Matrix Computations”, 3rd ed., Johns Hopkins Univ. Press, 1996. ISBN: 978-0-801-85414-9.
- G. Strang, “Linear Algebra and Its Applications, 2nd ed.”, Academic Press, 1980. ISBN: 0-12-673660-X.

Supplemental Materials

- ftp://ftp.wiley.com/public/sci_tech_med/filtering/
  - MATLAB programs to solve all computer projects

- Ali. H. Sayed, on-line course lectures.
  - UCLA: EE210A Adaptive Filtering
  - Additional Course Website:
    - http://asl.ee.ucla.edu/index.php?option=com_content&task=view&sectionid=10&id=214
  - On-line lectures using his other textbook
    - A newer version that is designed for a graduate class. It does not include as much material as this one and does not have some of the supporting material present in this text.

Identification and Acknowledgement

- Identification for Grade Posting,
  Course and University Policies, and
  Acknowledgement

- Please read, provide unique identification, sign and date,
  and return to Dr. Bazuin.

Course/Text Coverage Goals

Linear Estimation

- Chapter 1: OPTIMAL ESTIMATION
- Chapter 2: LINEAR ESTIMATION
- Chapter 3: CONSTRAINED LINEAR ESTIMATION

Stochastic Gradient Adaptive Methods

- Chapter 4: STEEPEST-DESCENT ALGORITHMS
- Chapter 5: STOCHASTIC-GRADIENT ALGORITHMS
- Chapter 10: BLOCK ADAPTIVE FILTERS

Performance Analysis

- Chapter 6: STEADY-STATE PERFORMANCE OF ADAPTIVE FILTERS
- Chapter 7: TRACKING PERFORMANCE OF ADAPTIVE FILTERS
- Chapter 8: FINITE PRECISION EFFECTS (brief)
- Chapter 9: TRANSIENT PERFORMANCE OF ADAPTIVE FILTERS

Least-Squares Adaptive Methods

- Chapter 11: THE LEAST-SQUARES CRITERION (brief)
- Chapter 12: RECURSIVE LEAST-SQUARES
- Chapter 13: RLS ARRAY ALGORITHMS (if time permits)

Chapter 14-17 Not Covered

Text Key Sections

- The key sections listed in the preface will be followed:
  - See Table P.4 on page xxvi.

- The lecture plan is:
  - to cover the material suggested,
  - include important aspects of in the chapter appendixes
  - Include example problems when the text and the homework "degree of difficulty" is significantly different.

  - Slip the plan as required based on this being the second course offering.

Impression from 2009

- Chap 1-4 is based on prerequisite mathematical concepts. Chap 5, with 4 as a setup, contains the dominant adaptive algorithms. Chap 6-9 provide steady state, transient steady state, numerical precision, and transient analysis. The use of ensemble average performance needs to be reviewed and included in Chap. 5 as a simulation technique for algorithm validation. Chap. 10 can be dealt with as prerequisite least-squares material with Chap 11 using the recursive least-squares algorithm.
- Block approaches to optimal filter generation are not specifically addresses. They would also help motivate linear algebra manipulations such as Cholesky factorization and QR decomposition. Cholesky and QR are introduced for LS methods and the RLS algorithm, but was only used as final exam material this time.
- A significant number of simulations are based on purely random input signals. More applicable communications or test signals need to be developed. An increase emphasis on blind-adaptive algorithms and analysis would be useful. There are very few examples with non-random signal examples of blind-adaptation. (PM or FM or an alternate constant modulus test signal must be developed.)
- One student had taken MATH 6050 Optimization which greatly enhanced their understanding of the introductory material.

Course Plan

Exam 1

- Chapter 1: OPTIMAL ESTIMATION
- Chapter 2: LINEAR ESTIMATION
- Chapter 3: CONSTRAINED LINEAR ESTIMATION

Exam 2

- Chapter 4: STEEPEST-DESCENT ALGORITHMS
- Chapter 5: STOCHASTIC-GRADIENT ALGORITHMS
- Chapter 6: STEADY-STATE PERFORMANCE OF ADAPTIVE FILTERS
- Chapter 7: TRACKING PERFORMANCE OF ADAPTIVE FILTERS
- Chapter 8: FINITE PRECISION EFFECTS (brief)
- Chapter 9: TRANSIENT PERFORMANCE OF ADAPTIVE FILTERS

Final Exam

- Chapter 10: BLOCK ADAPTIVE FILTERS
- Chapter 11: THE LEAST-SQUARES CRITERION
- Chapter 12: RECURSIVE LEAST-SQUARES
- Chapter 13: RLS ARRAY ALGORITHMS

Chapter 1: Optimal Estimation