Colorado State University, Ft. Collins **Spring Semester, 2010**

ECE 652: Estimation and Filtering Theory
3 cr Tues, Thurs 5:00pm-6:15pm Engr B4

Instructor: Prof. Louis Scharf
Office: B116
OH: After class on Tues and Thurs, 6:15pm-7:30pm, and by appointment
Extra Problem Sessions: To be organized by students

TA and Grader: None
OH: NA

WWW URLs:
http://www.engr.colostate.edu/EE652/
http://www.engr.colostate.edu/ecefaculty/scharf/courses/EE652/123html.

Calendar:

Jan 19:	First class, Engr B4, 5:00-6:15pm
Mar 11	Midterm Exam
Mar 15-19:	Spring Break
May 6:	Final Exam Projects

Textbook: T. Kailath, A.H. Sayed, and B. Hassibi, "Linear Estimation," Prentice-Hall, latest edition

References, selected, from early to late:

1. R. Kalman, "A new approach to linear filtering and prediction problems," Trans ASME J. Basic Eng., vol 82, pp 34-45, 1960

2. H. Cox, "On the estimation of etate variables and parameters for noisy dynamic systems," IEEE Trans Autom Contr, vol 9, no 1, pp 5-12, Jan 1964

3. M. Aoki, "Optimization of Stochastic Systems," Academic Press, 1967

4. R. Bucy, "Bayes Theorem and Digital Realizations for Nonlinear Filters," The Journ of Astronomical Sciences, vol 17, no 2, pp 80-94, Sept-Oct 1969

5. J. Meditch, "Stochastic Optimal Linear Estimation and Control," McGraw-Hill, 1969

6. A. Jazwinski, "Stochastic Processes and Filtering Theory," Academic Press, 1970

7. H. Sorenson,"Least squares estimation from Gauss to Kalman," IEEE Spectrum, vol 7, pp 63-68, 1970

8. A. Gelb, "Applied Optimal Estimation," MIT Press, Cambridge, MA 1974

9. B. Anderson and J. Moore, "Optimal Filtering," Prentice-Hall, 1979

10. R. Bellman, "Some Consequences of the Nonnegativity of the Elements of the Matrix Exponential," Nonlinear Analysis, Theory, Methods, and Applications, vol 4, no 4, pp 735-736, 1980

11. H. Sorenson, "Parameter Estimation," Marcel-Dekker, 1980

12. G. Goodwin and K. Sin, "Adaptive Filtering, Prediction, and Control," Prentice-Hall, 1984

13. H. Sorenson, "Kalman Filtering: Theory and Applications," IEEE Press, 1985

14. G. Golub and C. Van Loan, "Matrix Computations," The Johns Hopkins University Press, 1989

15. L.L. Scharf, "Statistical Signal Processing: Detection, Estimation, and Times series Analysis," Addison-Wesley, 1991

16. J.M. Mendel, "Lessons in Estimation Theory for Signal Processing," Prentice-Hall, 1995

17. E. Brookner, "Tracking and Kalman Filtering Made Easy," John Wiley and Sons, 1998

18. B. Ristic, S. Arulampalam, and N. Gordon, "Beyond the Kalman Filter: Particle Filters for Tracking Applications," Artech House, Norwell, MA 2004

19. D. Simon, "Optimal Estimation: Kalman, H_∞, and Nonlinear Approaches," Wiley-Interscience, 2006

Languages of Instruction: English, Mathematics, and MATLAB

Exams and Percent of Grade:

Homework and programs	50%
Midterm	25%
Final	25%

Homework: Assigned every Thurs and due at the start of class the next Thurs.

MATLAB Programs: Approximately 6, included as part of the weekly homework.

Course Objectives:

Detection, estimation, and time series analysis are the main branches of statistical signal processing. Estimation theory is perhaps the most fundamental of these three, as it plays an important role in the other two. Our objective is to lay the probabilistic foundations for estimation and then to develop its main lines, from parameter estimation to recursive least squares to Wiener and Kalman filtering. Then we address selected topics among linear prediction, modal analysis, multi-sensor array processing, time-frequency analysis, Gaussian sums, particle filtering, and the like.

Course Outline (provisional after first 6 topics, depending on student interest)

1. Deterministic least squares, including RLS
2. Stochastic least squares, including channel and filtering models
3. The Wiener filter, including spectral factorization
4. The Kalman filter
5. Linear prediction and modal analysis
6. Fast algorithms of the Levinson, Schur, conjugate gradient type
7. Multi-sensor array processing
8. Gaussian sums and particle filters
9. Time-Frequency analysis
10. HMM, Baum-Welch, and EM
11. Compressed sensing

MATLAB Experiments:

1. various experiments in numerical linear algebra
2. more to come

Assumed Input Skills:

1. Linear Systems Theory
2. Probability Theory
3. Rudiments of Complex Analysis

Presumed Output Skills:

1. Command of the course syllabus