332:525 – Optimum Signal Processing – Spring 2011

Course Description:

This course is an introduction to statistical signal processing methods and covers the theory, design, and applications of signal processing algorithms for optimum Wiener and Kalman filtering, linear prediction, signal modeling, and parametric spectrum estimation, explores their interconnections, and derives efficient and fast computational methods for their implementation.

Both block processing and adaptive processing methods are discussed, including several applications such as adaptive channel equalization, echo canceling, noise canceling, adaptive antennas, adaptive spectral analysis and harmonic retrieval, fast adaptive filters. Kalman filtering applications. SVD and its signal processing applications in parametric spectrum estimation, signal enhancement, compression, smoothing, inverse filtering, and signal modeling. Neural networks as generalizations of adaptive filtering algorithms may also be discussed if time permits.

The course includes several multidisciplinary topics drawn from engineering, climate, social, census, economic, business, and financial applications, such as exponential smoothing and other filtering methods for forecasting and financial market trading; Whittaker-Henderson smoothing methods, smoothing splines, Hodrick-Prescott and other optimum filters for trend extraction and business cycles; signal extraction methods for seasonal data; wavelet denoising; constrained optimization methods in smart antennas and optimum portfolio design in finance; convex optimization with emphasis on sparse signal processing and compressive sensing.

The course emphasizes computational aspects through the assignment of computer experiments illustrating the implementation and performance of the various algorithms.

Text:

S. J. Orfanidis, *Optimum Signal Processing*, 2nd ed., 2007 republication of the 1988 McGraw-Hill edition. The book may be freely downloaded in PDF format from the course web page. Class notes and papers covering further topics will also be used.

Prerequisites:

332:521 Digital Signals and Filters and familiarity with probability and stochastic processes (multidimensional gaussian distributions, conditional densities, autocorrelations and power spectra), and with linear algebra concepts (Cholesky factorizations, eigenvalue and SVD decompositions). Familiarity with C or MATLAB will be useful. Otherwise, permission of the instructor is required.

Course Requirements:

The final grade is based on:

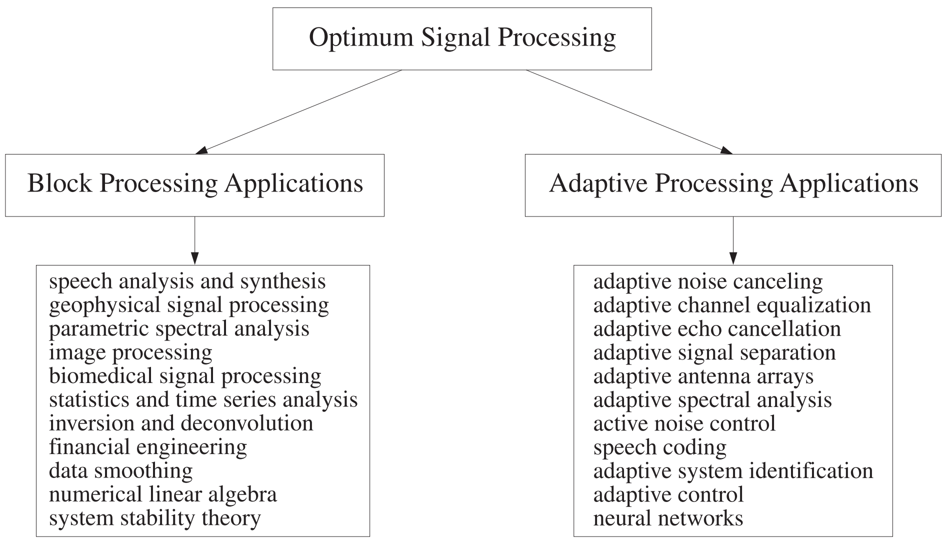
1. Final project
2. Two exams (dates: March 3 and April 7, 2011)
3. Computer projects and homework assignments

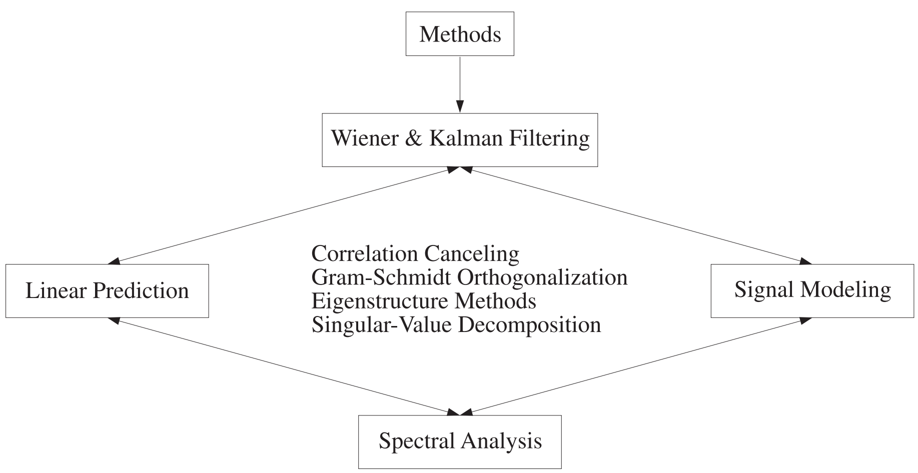
Instructor:

Sophocles J. Orfanidis
Room ELE-230, Tel. 445-5017, e-mail: `orfanidi@ece.rutgers.edu`.
Office hours by appointment.

Course Web Page:

`http://www.ece.rutgers.edu/~orfanidi/ece525/`


Optimum Signal Processing
Block Processing Applications
Adaptive Processing Applications
speech analysis and synthesis
geophysical signal processing
parametric spectral analysis
image processing
biomedical signal processing
statistics and time series analysis
inversion and deconvolution
financial engineering
data smoothing
numerical linear algebra
system stability theory
adaptive noise canceling
adaptive channel equalization
adaptive echo cancellation
adaptive signal separation
adaptive antenna arrays
adaptive spectral analysis
active noise control
speech coding
adaptive system identification
adaptive control
neural networks


Methods
Wiener & Kalman Filtering
Linear Prediction
Correlation Canceling
Gram-Schmidt Orthogonalization
Eigenstructure Methods
Singular-Value Decomposition
Signal Modeling
Spectral Analysis

332:525 – Reference Books

1. D. Manolakis, V. Ingle, S. Kogon, *Statistical and Adaptive Signal Processing*, McGraw-Hill, 2000.
2. M. H. Hayes, *Statistical Digital Signal Processing and Modeling*, Wiley, 1996.
3. C. W. Therrien, *Discrete Random Signals and Statistical Signal Processing*, Prentice Hall, 1992.
4. B. Widrow and S. D. Stearns, *Adaptive Signal Processing*, Prentice Hall, 1985.
5. A. Sayed, *Fundamentals of Adaptive Filtering*, Wiley-IEEE, 2003
6. S. Haykin, *Adaptive Filter Theory*, 4th ed., Prentice Hall, 2001.
7. R. T. Compton, *Adaptive Antennas*, Prentice Hall, 1988.
8. J. E. Hudson, *Adaptive Array Principles*, Stevenage, UK, Peter Peregrinus, 1981.
9. S. M. Kay, *Modern Spectral Estimation*, Prentice Hall, 1988.
10. S. L. Marple, *Digital Spectral Analysis with Applications*, Prentice Hall, 1987.
11. M. G. Bellanger, *Adaptive Digital Filters and Signal Analysis*, Marcel Dekker, 1987.
12. S. T. Alexander, *Adaptive Signal Processing*, Springer-Verlag, 1986.
13. T. W. Anderson, *An Introduction to Multivariate Statistical Analysis*, 2nd ed., Wiley, 1984.
14. P. J. Brockwell and R. A. Davis, *Time Series: Theory and Methods*, Springer-Verlag, 1987.