Department of Electrical and Computer Engineering
University of Massachusetts-Amherst
ECE608-Signal Theory
Spring 2017 Syllabus

Instructor

Prof. Weibo Gong, 211E Knowles Engineering Building, gong@ecs.umass.edu
Office Hour: TBD

Lectures

Marston 15 2:30pm-3:45pm Tuesday and Thursday

Description

This course will offer a unified treatment of techniques for representation of signals and signal processing operations. Emphasis will be given on the physical interpretation of vector spaces, linear operators, transform theory, and digital signal processing with wavelet filter banks. This course is an introduction to the mathematical foundations of signal processing. Students completing this course will know:

- The properties of linear and Hilbert spaces and their uses for signal representations.
- The principles of continuity, convergence, and orthogonal projection, and their applications in signal processing operations.
- Properties, representations and some applications of linear functionals and operators.
- The fundamental techniques for constrained and unconstrained optimization.

Prerequisites

The course is aimed for graduate students. Prerequisites include undergraduate-level linear algebra and signals and systems. As in many courses in signals and systems, a reasonable degree of mathematical sophistication will be very helpful.

Textbooks

While there is no single textbook that fits all the content of this course, the following two textbooks complementary covers most of the topics:

- Todd K. Moon and Wynn C. Stirling, Mathematical Methods and Algorithms for Signal Processing, Prentice Hall, 1999.

- David G. Luenberger, Optimization by Vector Space Methods, Wiley, New York, 1968.

The following books will also be useful: L. E. Franks, "Signal Theory", Prentice Hall, 1968; A. Mertins, "Signal Analysis", Wiley, 1999. L. Debnath and P. Mikusinski, Introduction to Hilbert Spaces.

Lecture Schedule

Part 1: Linear Spaces
Week 1: Introduction. Signal spaces. Vector spaces.
Week 2: Norms and normed vector spaces. Induced norms. Cauchy-Schwarz inequality.Orthogonality.
Part 2: Hilbert Spaces
Week 3: Inner products. Orthogonal subspaces. Linear transformations.
Week 4: Projections and orthogonal projections. Projection theorem.
Part 3: Approximation in Hilbert Spaces
Week 5: Orthogonality principle. Least squares.
Week 6: Complete orthonormal sequences. Fourier series.
Part 4: Linear Functionals and Operators
Week 7: Linear functionals. Dual spaces. Riesz representation theorem.
Week 8: Linear operators. Operator norms. Adjoint operators.
Week 9: Eigenvalues and eigenvectors. Singular value decomposition. Karhunen-Love transform.
Part 5: Local, Global, and Constrained Optimization
Week 10: Optimization in Hilbert space. Optimization of functionals.
Week 11: Directional derivatives and differentials. Euler-Lagrange equations.
Week 12: Convexity. Equality constraints. Lagrange multipliers.
Week 13: Inequality constraints. Kuhn-Tucker conditions.

Homework Assignments

There will be six homework assignments (one every two weeks).

It is encouraged to discuss the problem sets with others, but each student must turn in a unique personal write-up *Homework assignments are preparation for exams*, so do not rely too heavily on other students for help.

Grading

- Homework assignments : 20% of Grade
- Exam 1: 35% of Grade (Time and Place TBD)
- Exam 2: 35% of Grade (Time and Place TBD)
- Participation: 10% of Grade