EE599: Vector Space Methods for Signal Processing
Spring 2013

Instructor: Justin P. Haldar
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Office Hours: 3:30pm-5:00pm MW

Objectives: To provide a rigorous understanding of vector space and functional analysis concepts and tools that are commonly encountered in a variety of modern signal processing applications (e.g., signal compression, approximation, and restoration; linear inverse problems such as deconvolution, tomography, and Fourier imaging; spectrum estimation, beamforming, etc.). The course covers a range of advanced topics including linear inverse problems in finite and infinite dimensional vector spaces, the singular value decomposition and the Moore-Penrose pseudoinverse, conditioning and regularization, Banach and Hilbert spaces, optimal design of experiments, iterative methods for solving linear systems, subspace methods, constrained convex optimization, sparse and low-rank approximation, and compressed sensing.

Coursework will include proving theorems, deriving methods and algorithms for solving signal processing problems in vector spaces, and using Matlab to apply these methods to real-world signal processing problems.

Credit: 3.0 Units

Lectures: 2:00pm-3:20pm MW, Taper Hall (THH) B10

Grading: 30% Homework, Reading, and Matlab Assignments
30% Midterm (March 13th)
40% Final project presentation (April 29th or May 1st) and report (May 10th)

Prerequisites/Corequisites: EE 441 – Applied Linear Algebra for Engineering
EE 483 – Introduction to Digital Signal Processing
EE 464 – Probability Theory for Engineers

Course Outline (subject to change):

Week 1  Linear inverse problems in $\mathbb{C}^N$
Left and right inverses

Week 2  Projections
Minimum norm least squares solutions
Moore-Penrose pseudoinverse

Week 3  Singular value decomposition
Low-rank matrix approximation

Week 4  Conditioning and regularization
Total least squares
Subspace fitting

Week 5  Iterative methods for linear least squares problems
Design of experiments

Week 6  Applications in Harmonic Retrieval and Sensor Array Processing
Variable projection, MUSIC

Week 7  Normed vector spaces and inner product spaces
Linear operators

Week 8  Finite and infinite dimensional vector spaces

Week 9  Hilbert spaces and infinite dimensional linear inverse problems

Week 10  Bases and frames

Week 11  Hilbert spaces of random variables
Linear Minimum Variance and Best Linear Unbiased Estimation

Week 12  Topics in Constrained Convex Optimization:
Projection onto Convex Sets, Lagrange Multipliers

Week 13  Topics in Constrained Convex Optimization:
Nesterov’s Method, Alternating Direction Method of Multipliers

Week 14  Compressed sensing with sparsity and low-rank matrix constraints

Week 15  Project presentations
Statement for Students with Disabilities:

Any student requesting academic accommodations based on a disability is required to register with Disability Services and Programs (DSP) each semester. A letter of verification for approved accommodations can be obtained from DSP. Please be sure the letter is delivered to me (or to TA) as early in the semester as possible. DSP is located in STU 301 and is open 8:30 a.m.–5:00 p.m., Monday through Friday. The phone number for DSP is (213) 740-0776.

Statement on Academic Integrity:

USC seeks to maintain an optimal learning environment. General principles of academic honesty include the concept of respect for the intellectual property of others, the expectation that individual work will be submitted unless otherwise allowed by an instructor, and the obligations both to protect one’s own academic work from misuse by others as well as to avoid using another’s work as one’s own. All students are expected to understand and abide by these principles. Scampus, the Student Guidebook, contains the Student Conduct Code in Section 11.00, while the recommended sanctions are located in Appendix A:

http://www.usc.edu/dept/publications/SCAMPUS/gov/

Students will be referred to the Office of Student Judicial Affairs and Community Standards for further review, should there be any suspicion of academic dishonesty. The Review process can be found at:

http://www.usc.edu/studentaffairs/SJACS/