ELG 5385 – EACJ 5385

Matrix Methods and Algorithms for Signal Processing

Winter 2014

Professor: Dr. Abbas Yongacoglu, *P.Eng.*
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website: http://www.eecs.uottawa.ca/~yongacog/courses/matrixmethods
password will be provided in class

Lectures: Wednesday, 2:30 – 5:20 CBY B012

Pre-requisites: none

Corrector: Kai Gao (kgao097@uottawa.ca)

Grading Scheme: 40% assignments & small projects
20% Midterm
40% final exam

Text: Mathematical Methods and Algorithms for Signal Processing, Moon and Stirling, Prentice Hall, 2000.

Course Notes: available on the course website

Calendar description: Metric spaces, representation and approximation in vector spaces, matrix factorization, application of eigen decomposition methods, singular value decomposition, total least squares problems, applications of special matrices, iterative algorithms

Week-by-week Description:

Week 1 Review: metric spaces, normed vector spaces, induced norms, Cauchy-Schwartz inequality,

Week 2 inner-product spaces, Hilbert and Banach spaces, linear transformations, orthogonal spaces and orthogonalization

Week 3 Approximation in vector spaces, error minimization via gradients, matrix representation of least squares problems, minimum error in Hilbert space

Week 4 Linear operators, operator norms, adjoint operators and transposes, geometry of linear equations, some properties of matrix inverses and matrix rank, pseudoinverses

Week 5-6 Some important Matrix Factorizations: LU, Cholesky, Unitary matrices and QR decomposition.

Week 7-8 Eigenvalues and eigenvectors: eigenvalues and linear systems, diagonalization of a matrix, geometry of invariant subspaces, application of eigen decomposition methods: eigenfilters, signal subspace techniques, generalized eigenvalues, matching pursuit algorithms

Week 9-10 Singular Value Decomposition (SVD), matrix structure of SVD, pseudoinverses and SVD, applications of SVD: system identification using SVD, total least squares problems

Week 11 Principal Component Analysis

Week 12 (If time permits) Expectation Maximization (EM) algorithm, and example applications of the EM algorithm, iterative algorithms, basic theorems of convergence for iterative algorithms,

Rationale: In recent years many students doing their graduate work in communications and signal processing use MATLAB extensively. They have a very limited knowledge of matrix algebra, with not much appreciation of their practical uses and the underlying theory. One common complaint they have is the lack of in-depth understanding of the algorithms and methods used. Most of my own graduate students had to learn the contents of this course on their own, without a structure. This course tries to fill this void. After a review of the preliminary concepts, this course will deal with some of the most frequently used signal processing and communication algorithms and methods.

Schedule: Midterm: Feb. 26 (1.5 hours)
If everyone agrees, one extra class on Feb. 19
Last lecture on March 26
Final exam: 3 hours, date between March 28 and Apr. 1