Spring 2020

MA/CS 622 Matrix Theory and Numerical Linear Algebra II.

MWF 01:00-01:50 - CB

Instructor: Dr. Qiang Ye
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Syllabus: The course studies sparse matrix techniques and modern iterative methods such as Krylov subspace projection methods for solving large scale linear algebra problems (linear systems of equations and matrix eigenvalue problems). Applications to discretization of PDES, spectral graph theory, and unsupervised machine learning will be covered. The following is a list of topics.

- Finite difference discretization of elliptic PDEs; Discrete convolution and Fast Fourier Transform; Fast Poisson solver.
- Adjacency graphs and sparse matrix techniques.
- Iterative methods for systems of linear equations:
  - — Jacobi, Gauss-Seidel, SOR, Chebyshev iterations, conjugate gradient (CG), BiCGSTAB, and GMRES methods.
  - — Preconditioning and ILU factorization
- Large sparse eigenvalue problems
  - — Minimax Theorem and trace minimization; Spectral partitioning of graphs;
  - — Dimension reduction in machine learning (PCA, MDS, LLE, ISOMAP, LTSA);
  - — Lanczos Algorithm, Arnoldi Algorithm, Shift-and-invert preconditioning

There will be no required text. The coverage of iterative methods and sparse matrix techniques will be based on *Applied Numerical Linear Algebra* by James Demmel (SIAM, 1997) and *Iterative Methods for Sparse Linear Systems* by Y. Saad, PWS Publishing, Boston, MA, 1996 (available at `http://www-users.cs.umn.edu/ saad/books.html`). Other materials will be taken from various sources.

Prerequisites: Good knowledge of linear algebra at the level of MA322 or equivalent, programming experience, numerical sophistication at the level of MA/CS 321 or equivalent. MA/CS 522 will be helpful but *not* required.

Grading: Grading will be based on homeworks (80%) and a take-home final exam (20%).