Numerical Linear Algebra

General Course Information

Objectives: Students will learn the basic direct methods for solving system of linear equations and linear least square equations, matrix factorization methods, basic computer arithmetic and the concepts of conditioning and stability of a numerical method, numerical methods for computing eigenvalues and their derivation, basic iterative methods, singular value decomposition . They will also improve their problem solving skills in computational linear algebra.

Note: Most important material of the course will be presented in class, so attendance is imperative.

Textbooks:

- N. Trefethen and Bau, Numerical Linear Algebra, SIAM (1997).
- Carl D. Meyer, Matrix Analysis and Applied Linear Algebra, SIAM (2000).
- J. W. Demmel, Applied Numerical Linear Algebra, SIAM(1997).
- G. H. Golub and C. F. Van Loan, Matrix Computations (3rd Ed.), Jhons Hopkins Univ. Press (1996).
- G. Sewell, Computational Methods of Linear Algebra (2nd Ed.), John Willey (2005).
- B. N. Datta, Numerical Linear Algebra and Applications, Brooks /Cole Publishing (1995).

Course Outline:

1. **Foundamemtals**
   - Matrix-vector multiplication
   - Orthogonal vectors and matrices
   - Norms
2. **Direct Methods**
   - Guassian elimination
   - LU Decomposition
   - Cholesky factorization
   - Guass-Jordan Method
   - QR decomposition
3. **Conditioning and stability**
   - Conditioning and condition number
   - Stability
   - Perturbation analysis in linear systems

4. **Iterative methods**
   - Overview of iterative methods
   - Conjugate gradients
   - GMRES
   - Preconditioning

5. **Eigenvalue Problem**
   - Overview of eigenvalue algorithms
   - The Power method
   - Reduction to Hessenberg or tridiagonal form
   - Rayleigh quotient, Inverse iteration
   - QR algorithm without and with shifts
6. **QR factorization and least squares**
   - Projectors
   - QR factorization
   - Gram-Schmidt orthogonalization
   - Householder triangularization
   - Least square problems
   - Algorithms for finding the Least Squares Solution
7. **Singular value Decomposition**
   - Full SVD
   - SVD as a change of basis
   - Low-rank approximation
8. **Solution of Nonlinear Systems**

Assessment:

Homework and class presentation	15%
Computer Programs/Project	15%
Midterm	20%
Final Exam	50%