CPSC 542g
Introduction to Numerical Methods

U. M. Ascher
ascher@cs.ubc.ca
604-822-4907
CS/ICICS 223
Fall 2013, TR 11:00-12:30, ICCS 206. First lecture: Thu Sept. 5.

This course is intended for relatively new graduate students who require knowledge of and background in numerical methods. Thus, it is a graduate breadth course.

For each of the topics that are typically addressed in an introductory numerical course sequence there will be a few lectures covering basic concepts and methods as well as lectures surveying more advanced, related issues and developments. Some case studies illustrating the concepts will also be presented as time allows.

A recent book by Ascher and Greif will be used as background material.

http://people.cs.ubc.ca/∼ascher/542g.html

Tentative course outline

1. Scientific computing and roundoff error [1 lecture +]
   (a) Introduction
   (b) Roundoff, discretization and convergence errors
   (c) Floating point computation, roundoff error propagation, IEEE standard
2. Nonlinear equations [1 week -]
   (a) Newton's method, fixed point iteration, bisection
   (b) Order and rate of convergence
   (c) Systems of equations
3. Linear systems [2 weeks -]
   (a) Eigenvalues, SVD and singularity
   (b) Gaussian elimination, LU decomposition, banded matrices
   (c) Pivoting
   (d) * Efficient implementation, BLAS and sparse matrices

(e) Problem conditioning and error estimation

4. Least squares [1 week]
   (a) * Data fitting
   (b) Normal equations and conditioning
   (c) Orthogonal transformations and QR
   (d) * Ill-posed problems and regularization
5. Linear systems and iterative methods [2 weeks +]
   (a) * Power method and Google's PageRank
   (b) * Poisson's PDE: finite difference and finite element approximations
   (c) Stationary methods: Jacobi, Gauss-Seidel, SOR and ILU
   (d) Gradient descent and conjugate gradients (CG) for positive definite systems
   (e) Preconditioning
   (f) * Krylov space methods
   (g) * Multigrid
6. Continuous optimization [1 week -]
   (a) Unconstrained optimization: Newton, quasi-Newton, gradient descent
   (b) * Constrained optimization: KKT, linear programming, sparse solutions.
7. Interpolation [2 weeks -]
   (a) Polynomial: Lagrange and Newton forms
   (b) Piecewise polynomial: broken line, Hermite, spline
   (c) * Parametric curve, Bezier polynomials
   (d) * Multi-dimensional: tensor products, triangles and tetrahedra, scattered data
8. Fourier transform methods [1 week]
   (a) Continuous and discrete Fourier transform
   (b) * Fast matrix-vector multiplication: fast Fourier transform (FFT)
   (c) * Image processing and spectral methods
9. Initial value differential equations [2 weeks -]

(a) * Initial value problems, heat and wave equations, method of lines

(b) Euler, Runge-Kutta and multistep methods

(c) Stiffness and implicit methods

(d) * Symplectic, variational, splitting and implicit-explicit methods