

Seminar - Computer Algorithms in Applied Mathematics

Topic Suggestions

Linear Systems of Equations

- Krylov subspace methods like GMRES, BiCGSTAB, Arnoldi, Lanczos, etc. for sparse, block, and banded matrices (D). **Literature: Golub/van Loan - Matrix Computations Chap. 11.1,3,4, Saad, Schultz - GMRES, Freund et al. - Iterative Solution of Linear Systems**
- Preconditioning with SOR, Multigrid, ILU and incomplete Cholesky, reduction of fill-in using the Cuthill-McKee Algorithm (A). **Literature: Golub/van Loan - Matrix Computations Chap. 11.5, Kuthill et al., Reducing the bandwidth of sparse symmetric matrices**
- Strassen's algorithm and Strassen tensor (D). **Literature: Strassen - Gaussian elimination is not optimal, Coppersmith/Winograd - On the asymptotic complexity of matrix multiplication, Bläser - A $\frac{5}{2}n^2$ -Lower Bound for the Rank of $n \times n$ -Matrix Multiplication over Arbitrary Fields**

Eigenvalue Problems

- Matrix functions, matrix exponential, and Pade approximation (A). **Literature: Golub/van Loan - Matrix Computations Chap. 9.3, Arioli - The Pade method for computing the matrix exponential**

Interpolation and Approximation

- Radial Basis Functions (D). **Literature: Schaback - A practical guide to radial basis functions, Buhmann - Radial Basis Functions**
- Regression analysis, least squares, linear, nonlinear regression, etc. (A). **Literature: Bates et al. - Nonlinear Regression Analysis and Its Applications**
- B-Splines, Bézier curves, surfaces and their evaluation using the De-Casteljau and De-Boor algorithms.
- NURBS and igA.

Numerical Quadrature

- Féjer or Clenshaw-Curtis quadrature and sparse-grids (D). **Literature: Trefethen - Is Gauss Quadrature better than Clenshaw-Curtis?, Gerstner/Griebel - Numerical integration using sparse grids**
- (Quasi-) Monte Carlo methods for high-dimensional integrals, Weyl's theorem (A). **Literature: Random Number Generation and Quasi-Monte Carlo Methods**
- Trapezoidal rule for periodic functions (Euler-MacLaurin formula).
- Quadrature for triangles, rectangles, spheres.

Nonlinear Systems of Equations

- Newton's method with constraints, line search, and trust region (D). **Literature: Deuffhard - Newton Methods for Nonlinear Problems, Nocedal/Wright - Numerical Optimization**
- Simplex algorithm for linear optimization problems (A). **Literature: Chvatal - Linear Programming**
- Integer programming, Branch & Cut.

Low Rank Decomposition

- Eckart-Young-Mirsky theorem, rank-revealing QR, ACA (D). **Literature: Eckart/Young - The approximation of one matrix by another of lower rank, Bebendorf - Hierarchical Matrices, Gu/Eisenstat - An efficient Algorithm for Computing a Strong Rank-Revealing QR Factorization, Hackbusch - Tensor spaces and numerical tensor calculus**

Additional Topics

- Discrete Fourier Transformation, Wavelets