

Wolfgang Hackbusch

Hierarchical Matrices: Algorithms and Analysis

Ebook Online Hierarchical Matrices Algorithms Computational Mathematics

**Gene Howard Golub, Charles F. Van
Loan**



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Hierarchical Matrices: Algorithms and Analysis Wolfgang Hackbusch, 2015-12-21 This self contained monograph presents matrix algorithms and their analysis The new technique enables not only the solution of linear systems but also the approximation of matrix functions e g the matrix exponential Other applications include the solution of matrix equations e g the Lyapunov or Riccati equation The required mathematical background can be found in the appendix The numerical treatment of fully populated large scale matrices is usually rather costly However the technique of hierarchical matrices makes it possible to store matrices and to perform matrix operations approximately with almost linear cost and a controllable degree of approximation error For important classes of matrices the computational cost increases only logarithmically with the approximation error The operations provided include the matrix inversion and LU decomposition Since large scale linear algebra problems are standard in scientific computing the subject of hierarchical matrices is of interest to scientists in computational mathematics physics chemistry and engineering

External Memory Algorithms James M. Abello, Jeffrey Scott Vitter, 1999-01-01 This volume presents new research results and current techniques for the design and analysis of external memory algorithms Topics presented include problems in computational geometry graph theory data compression disk scheduling linear algebra statistics software libraries text and string processing visualization wavelets and industrial applications

High Performance Algorithms for Structured Matrix Problems Peter Arbenz, 1998 Comprises 10 contributions that summarize the state of the art in the areas of high performance solutions of structured linear systems and structured eigenvalue and singular value problems Topics covered range from parallel solvers for sparse or banded linear systems to parallel computation of eigenvalues and singular values of tridiagonal and bidiagonal matrices Specific paper topics include the stable parallel solution of general narrow banded linear systems efficient algorithms for reducing banded matrices to bidiagonal and tridiagonal form a numerical comparison of look ahead Levinson and Schur algorithms for non Hermitian Toeplitz systems and parallel CG methods automatically optimized for PC and workstation clusters Annotation copyrighted by Book News Inc Portland OR

Eigenvalue Algorithms for Symmetric Hierarchical Matrices Thomas Mach, 2012

Hierarchical Matrices Mario Bebendorf, 2008-06-25 Hierarchical matrices are an efficient framework for large scale fully populated matrices arising e g from the finite element discretization of solution operators of elliptic boundary value problems In addition to storing such matrices approximations of the usual matrix operations can be computed with logarithmic linear complexity which can be exploited to setup approximate preconditioners in an efficient and convenient way Besides the algorithmic aspects of hierarchical matrices the main aim of this book is to present their theoretical background The book contains the existing approximation theory for elliptic problems including partial differential operators with nonsmooth coefficients Furthermore it presents in full detail the adaptive cross approximation method for the efficient treatment of integral operators with non local kernel functions The theory is supported by many numerical experiments from

real applications *Matrix Algorithms* G. W. Stewart, 1998-08-01 This volume is the first in a self contained five volume series devoted to matrix algorithms It focuses on the computation of matrix decompositions that is the factorization of matrices into products of similar ones The first two chapters provide the required background from mathematics and computer science needed to work effectively in matrix computations The remaining chapters are devoted to the LU and QR decompositions their computation and applications The singular value decomposition is also treated although algorithms for its computation will appear in the second volume of the series The present volume contains 65 algorithms formally presented in pseudocode Other volumes in the series will treat eigensystems iterative methods sparse matrices and structured problems The series is aimed at the nonspecialist who needs more than black box proficiency with matrix computations To give the series focus the emphasis is on algorithms their derivation and their analysis The reader is assumed to have a knowledge of elementary analysis and linear algebra and a reasonable amount of programming experience typically that of the beginning graduate engineer or the undergraduate in an honors program Strictly speaking the individual volumes are not textbooks although they are intended to teach the guiding principle being that if something is worth explaining it is worth explaining fully This has necessarily restricted the scope of the series but the selection of topics should give the reader a sound basis for further study **A collection of matrices for testing computational algorithms** Robert T. Gregory, David L. Karney, 1978 **Numerical Methods in Matrix Computations** Åke Björck, 2014-10-07 Matrix algorithms are at the core of scientific computing and are indispensable tools in most applications in engineering This book offers a comprehensive and up to date treatment of modern methods in matrix computation It uses a unified approach to direct and iterative methods for linear systems least squares and eigenvalue problems A thorough analysis of the stability accuracy and complexity of the treated methods is given Numerical Methods in Matrix Computations is suitable for use in courses on scientific computing and applied technical areas at advanced undergraduate and graduate level A large bibliography is provided which includes both historical and review papers as well as recent research papers This makes the book useful also as a reference and guide to further study and research work Functions of Matrices Nicholas J. Higham, 2008-01-01 A thorough and elegant treatment of the theory of matrix functions and numerical methods for computing them including an overview of applications new and unpublished research results and improved algorithms Key features include a detailed treatment of the matrix sign function and matrix roots a development of the theory of conditioning and properties of the Fréchet derivative Schur decomposition block Parlett recurrence a thorough analysis of the accuracy stability and computational cost of numerical methods general results on convergence and stability of matrix iterations and a chapter devoted to the f A b problem Ideal for advanced courses and for self study its broad content references and appendix also make this book a convenient general reference Contains an extensive collection of problems with solutions and MATLAB implementations of key algorithms *Structured Matrices and Polynomials* Victor Pan, 2001-06-26 This user friendly engaging textbook makes

the material accessible to graduate students and new researchers who wish to study the rapidly exploding area of computations with structured matrices and polynomials The book goes beyond research frontiers and apart from very recent research articles includes previously unpublished results Fast Algorithms for Structured Matrices Vadim Olshevsky,2003 One of the best known fast computational algorithms is the fast Fourier transform method Its efficiency is based mainly on the special structure of the discrete Fourier transform matrix Recently many other algorithms of this type were discovered and the theory of structured matrices emerged This volume contains 22 survey and research papers devoted to a variety of theoretical and practical aspects of the design of fast algorithms for structured matrices and related issues Included are several papers containing various affirmative and negative results in this direction The theory of rational interpolation is one of the excellent sources providing intuition and methods to design fast algorithms The volume contains several computational and theoretical papers on the topic There are several papers on new applications of structured matrices e g to the design of fast decoding algorithms computing state space realizations relations to Lie algebras unconstrained optimization solving matrix equations etc The book is suitable for mathematicians engineers and numerical analysts who design study and use fast computational algorithms based on the theory of structured matrices *Structured Matrices* Dario Bini,Plamen Yalamov,2001 Mathematicians from various countries assemble computational techniques that have developed and described over the past two decades to analyze matrices with structure which are encountered in a wide variety of problems in pure and applied mathematics and in engineering The 16 studies are on asymptotical spectral properties algorithm design and analysis issues specifically relating to structures algebras and polynomials and image processing and differential equations c Book News Inc *Matrix Methods* Vadim Olshevsky,2010 Matrix methods provide the key to many problems in pure and applied mathematics However linear algebra theory numerical algorithms and matrices in FEM BEM applications usually live as if in three separate worlds In this volume maybe for the first time ever they are compiled together as one entity as it was at the Moscow meeting where the algebraic part was impersonated by Hans Schneider algorithms by Gene Golub and applications by Guri Marchuk All topics intervened in plenary sessions are specially categorized into three sections of this volume Fast Reliable Algorithms for Matrices with Structure T. Kailath,A. H. Sayed,1999-01-01 This book deals with the combined issues of speed and numerical reliability in algorithm development Matrix Algorithms G. W. Stewart,2001-08-30 This is the second volume in a projected five volume survey of numerical linear algebra and matrix algorithms It treats the numerical solution of dense and large scale eigenvalue problems with an emphasis on algorithms and the theoretical background required to understand them The notes and reference sections contain pointers to other methods along with historical comments The book is divided into two parts dense eigenproblems and large eigenproblems The first part gives a full treatment of the widely used QR algorithm which is then applied to the solution of generalized eigenproblems and the computation of the singular value decomposition The second part treats Krylov sequence methods

such as the Lanczos and Arnoldi algorithms and presents a new treatment of the Jacobi Davidson method These volumes are not intended to be encyclopedic but provide the reader with the theoretical and practical background to read the research literature and implement or modify new algorithms

Matrix Computations Gene Howard Golub, Charles F. Van Loan, 2013-02-15 This revised edition provides the mathematical background and algorithmic skills required for the production of numerical software It includes rewritten and clarified proofs and derivations as well as new topics such as Arnoldi iteration and domain decomposition methods

Matrices, Moments and Quadrature with Applications Gene H. Golub, Gérard Meurant, 2009-12-07 This computationally oriented book describes and explains the mathematical relationships among matrices moments orthogonal polynomials quadrature rules and the Lanczos and conjugate gradient algorithms The book bridges different mathematical areas to obtain algorithms to estimate bilinear forms involving two vectors and a function of the matrix The first part of the book provides the necessary mathematical background and explains the theory The second part describes the applications and gives numerical examples of the algorithms and techniques developed in the first part Applications addressed in the book include computing elements of functions of matrices obtaining estimates of the error norm in iterative methods for solving linear systems and computing parameters in least squares and total least squares and solving ill posed problems using Tikhonov regularization This book will interest researchers in numerical linear algebra and matrix computations as well as scientists and engineers working on problems involving computation of bilinear forms

The Science of High Performance Algorithms for Hierarchical Matrices Chen-Han Yu (Ph. D.), 2018 Many matrices in scientific computing statistical inference and machine learning exhibit sparse and low rank structure Typically such structure is exposed by appropriate matrix permutation of rows and columns and exploited by constructing an hierarchical approximation That is the matrix can be written as a summation of sparse and low rank matrices and this structure repeats recursively Matrices that admit such hierarchical approximation are known as hierarchical matrices H matrices in brief H matrix approximation methods are more general and scalable than solely using a sparse or low rank matrix approximation Classical numerical linear algebra operations on H matrices multiplication factorization and eigenvalue decomposition can be accelerated by many orders of magnitude Although the literature on H matrices for problems in computational physics low dimensions is vast there is less work for generalization and problems appearing in machine learning Also there is limited work on high performance computing algorithms for pure algebraic H matrix methods This dissertation tries to address these open problems on building hierarchical approximation for kernel matrices and generic symmetric positive definite SPD matrices We propose a general tree based framework GOFMM for appropriately permuting a matrix to expose its hierarchical structure GOFMM supports both static and dynamic scheduling shared memory and distributed memory architectures and hardware accelerators The supported algorithms include kernel methods approximate matrix multiplication and factorization for large sparse and dense matrices

Matrices and Simplex Algorithms Aart R.

Heesterman,2012-12-06 This is a textbook devoted to mathematical programming algorithms and the mathematics needed to understand such algorithms It was mainly written for economists but the mathematics itself obviously has relevance for other disciplines It is a textbook as well a in parts a contribution to new knowledge There is accordingly a broad ordering of climbing sophistication the earlier chapters being purely for the student the later chapters being more specialist and containing some element of novelty on certain points The book is edited in five parts Part I deals with elementary matrix operations matrix inversion determinants etc Part II is mainly devoted to linear programming As far as students readability is concerned these two parts are elementary undergraduate material However I would claim in particular with respect to linear programming that I do things more efficiently than the standard textbook approach has it This refers mainly to the search for a feasible solution i e Chapter 9 and to upper and lower limits i e Chapter 10 I have also argued that the standard textbook treatment of degeneracy misses a relevant problem namely that of accuracy In short I would invite anyone who has the task of writing or designing an LP code to first acquaint himself with my ideas viii INTRODUCTION Parts III and IV are concerned with nonlinear programming **Separable Type Representations of Matrices and Fast Algorithms** Yuli Eidelman,Israel

Gohberg,Iulian Haimovici,2013-10-08 This two volume work presents a systematic theoretical and computational study of several types of generalizations of separable matrices The main attention is paid to fast algorithms many of linear complexity for matrices in semiseparable quasiseparable band and companion form The work is focused on algorithms of multiplication inversion and description of eigenstructure and includes a large number of illustrative examples throughout the different chapters The first volume consists of four parts The first part is of a mainly theoretical character introducing and studying the quasiseparable and semiseparable representations of matrices and minimal rank completion problems Three further completions are treated in the second part The first applications of the quasiseparable and semiseparable structure are included in the third part where the interplay between the quasiseparable structure and discrete time varying linear systems with boundary conditions play an essential role The fourth part contains factorization and inversion fast algorithms for matrices via quasiseparable and semiseparable structure The work is based mostly on results obtained by the authors and their coauthors Due to its many significant applications and the accessible style the text will be useful to engineers scientists numerical analysts computer scientists and mathematicians alike

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