Direct Methods for Sparse Linear Systems

Timothy A. Davis

SIAM

Direct Methods For Sparse Linear Systems

Gilbert Strang

Direct Methods For Sparse Linear Systems:

Direct Methods for Sparse Linear Systems Timothy A. Davis,2006-09-01 The sparse backslash book Everything you wanted to know but never dared to ask about modern direct linear solvers Chen Greif Assistant Professor Department of Computer Science University of British Columbia Overall the book is magnificent It fills a long felt need for an accessible textbook on modern sparse direct methods Its choice of scope is excellent John Gilbert Professor Department of Computer Science University of California Santa Barbara Computational scientists often encounter problems requiring the solution of sparse systems of linear equations Attacking these problems efficiently requires an in depth knowledge of the underlying theory algorithms and data structures found in sparse matrix software libraries Here Davis presents the fundamentals of sparse matrix algorithms to provide the requisite background The book includes CSparse a concise downloadable sparse matrix package that illustrates the algorithms and theorems presented in the book and equips readers with the tools necessary to understand larger and more complex software packages With a strong emphasis on MATLAB and the C programming language Direct Methods for Sparse Linear Systems equips readers with the working knowledge required to use sparse solver packages and write code to interface applications to those packages The book also explains how MATLAB performs its sparse matrix computations Audience This invaluable book is essential to computational scientists and software developers who want to understand the theory and algorithms behind modern techniques used to solve large sparse linear systems The book also serves as an excellent practical resource for students with an interest in combinatorial scientific computing Preface Chapter 1 Introduction Chapter 2 Basic algorithms Chapter 3 Solving triangular systems Chapter 4 Cholesky factorization Chapter 5 Orthogonal methods Chapter 6 LU factorization Chapter 7 Fill reducing orderings Chapter 8 Solving sparse linear systems Chapter 9 CSparse Chapter 10 Sparse matrices in MATLAB Appendix Basics of the C programming language Bibliography Index Direct Methods for Sparse Linear Systems Timothy A. Davis,2006-01-01 Presents the fundamentals of sparse matrix algorithms to provide the requisite background The book includes CSparse a concise downloadable sparse matrix package that illustrates the algorithms and theorems presented in the book and equips readers with the tools necessary to understand larger and more complex software packages *Direct Methods for Sparse Linear Systems* Joseph M. Elble,2007 *Elektrische Antriebe - Regelung von Antriebssystemen* Dierk Schröder,2015-11-30 Elektrische Antriebe Regelung von Antriebssystemen ist Teil eines f nfb ndigen Lehr und Nachschlagewerkes Die bew hrte Struktur mit der Dreiteilung regelungstechnische Grundlagen Regelung der elektrischen Maschinen und Regelung der elektrischen Antriebe in unterschiedlichsten Anwendungen bleibt erhalten In der 4 Auflage wurden Anpassungen an den Stand der Technik sowie folgende Erweiterungen vorgenommen Vergleich und Literatur bersicht von Statorstrom Regelungen unter Beachtung der berkreuzkopplungen der Kompensation der Gegenspannungen und der Polverschiebungen Resonanter P Regler Kaskadierte Zustandsregelung Polfesselung Die Regelung von Drehfeldmaschinen ohne Drehzahlsensor

wurde um die Realisierungen mittels Injektion von h herfrequenten Identifikationssignalen und um eine bersicht ber konstruktive Ma nahmen zur Verbesserung bzw dem Erzielen der Anisotrophie erweitert Die Regelung von technologischen Systemen wurde um die Regelung von Rollendruckmaschinen erg nzt Es folgen zwei neue Kapitel zu Aufbau Modellbildung und Regelung sowie zu den zuk nftigen Anforderungen an Windkraftwerke Im Kapitel Proper Orthogonal Decomposition POD wird die Reduzierung der Ordnung und die Optimalsteuerung von linearen aber auch nichtlinearen Systemen sehr hoher Ordnung vorgestellt Weitere Erg nzungen erfolgen mit den Kapiteln instabile Diskretisierungs Nullstellen Lund Grenoble Reibungsmodell und Vermeidung von Sensor bersteuerung **Iterative Methods for Sparse Linear Systems** Yousef Saad,2003-01-01 Since the first edition of this book was published in 1996 tremendous progress has been made in the scientific and engineering disciplines regarding the use of iterative methods for linear systems The size and complexity of the new generation of linear and nonlinear systems arising in typical applications has grown Solving the three dimensional models of these problems using direct solvers is no longer effective At the same time parallel computing has penetrated these application areas as it became less expensive and standardized Iterative methods are easier than direct solvers to implement on parallel computers but require approaches and solution algorithms that are different from classical methods Iterative Methods for Sparse Linear Systems Second Edition gives an in depth up to date view of practical algorithms for solving large scale linear systems of equations These equations can number in the millions and are sparse in the sense that each involves only a small number of unknowns The methods described are iterative i e they provide sequences of approximations that will converge to the solution Krylov Subspace Methods for Linear Systems Tomohiro Sogabe,2023-01-20 This book focuses on Krylov subspace methods for solving linear systems which are known as one of the top 10 algorithms in the twentieth century such as Fast Fourier Transform and Quick Sort SIAM News 2000 Theoretical aspects of Krylov subspace methods developed in the twentieth century are explained and derived in a concise and unified way Furthermore some Krylov subspace methods in the twenty first century are described in detail such as the COCR method for complex symmetric linear systems the BiCR method and the IDR s method for non Hermitian linear systems The strength of the book is not only in describing principles of Krylov subspace methods but in providing a variety of applications shifted linear systems and matrix functions from the theoretical point of view as well as partial differential equations computational physics computational particle physics optimizations and machine learning from a practical point of view The book is self contained in that basic necessary concepts of numerical linear algebra are explained making it suitable for senior undergraduates postgraduates and researchers in mathematics engineering and computational science Readers will find it a useful resource for understanding the principles and properties of Krylov subspace methods and correctly using those methods for solving problems in the future Graph Database and Graph Computing for Power System Analysis Renchang Dai,Guangyi Liu,2023-10-17 Graph Database and Graph Computing for Power System Analysis Understand a new way to model power systems with this comprehensive and

practical guide Graph databases have become one of the essential tools for managing large data systems Their structure improves over traditional table based relational databases in that it reconciles more closely to the inherent physics of a power system enabling it to model the components and the network of a power system in an organic way The authors pioneering research has demonstrated the effectiveness and the potential of graph data management and graph computing to transform power system analysis Graph Database and Graph Computing for Power System Analysis presents a comprehensive and accessible introduction to this research and its emerging applications Programs and applications conventionally modeled for traditional relational databases are reconceived here to incorporate graph computing The result is a detailed guide which demonstrates the utility and flexibility of this cutting edge technology The book s readers will also find Design configurations for a graph based program to solve linear equations differential equations optimization problems and more Detailed demonstrations of graph based topology analysis state estimation power flow analysis security constrained economic dispatch automatic generation control small signal stability transient stability and other concepts analysis and applications An authorial team with decades of experience in software design and power systems analysis Graph Database and Graph Computing for Power System Analysis is essential for researchers and academics in power systems analysis and energy related fields as well as for advanced graduate students looking to understand this particular set of technologies

Parallel Computing in Optimization A. Migdalas,Panos M. Pardalos,Sverre Storøy,2013-12-01 During the last three decades breakthroughs in computer technology have made a tremendous impact on optimization In particular parallel computing has made it possible to solve larger and computationally more difficult prob lems This volume contains mainly lecture notes from a Nordic Summer School held at the Linkoping Institute of Technology Sweden in August 1995 In order to make the book more complete a few authors were invited to contribute chapters that were not part of the course on this first occasion The purpose of this Nordic course in advanced studies was three fold One goal was to introduce the students to the new achievements in a new and very active field bring them close to world leading researchers and strengthen their competence in an area with internationally explosive rate of growth A second goal was to strengthen the bonds between students from different Nordic countries and to encourage collaboration and joint research ventures over the borders In this respect the course built further on the achievements of the Nordic Network in Mathematical Programming which has been running during the last three years with the support ofthe Nordic Council for Advanced Studies NorFA The final goal was to produce literature on the particular subject which would be available to both the participating students and to the students of the next generation **Understanding and Implementing the Finite Element Method** Mark S. Gockenbach,2006-01-01 The nite element method is the most powerful general purpose technique for comput ing accurate solutions to partial differential equations Understanding and Implementing the Finite Element Method is essential reading for those interested in understanding both the theory and the implementation of the nite element method for equilibrium problems This book

contains a thorough derivation of the finite element equations as well as sections on programming the necessary calculations solving the finite element equations and using a posteriori error estimates to produce validated solutions Accessible introductions to advanced topics such as multigrid solvers the hierarchical basis conjugate gradient method and adaptive mesh generation are provided Each chapter ends with exercises to help readers master these topics Understanding and Implementing the Finite Element Method includes a carefully documented collection of MATLAB programs implementing the ideas presented in the book Readers will bene t from a careful explanation of data structures and speci c coding strategies and will learn how to write a nite element code from scratch Students can use the MATLAB codes to experiment with the method and extend them in various ways to learn more about programming nite elements This practical book should provide an excellent foundation for those who wish to delve into advanced texts on the subject including advanced undergraduates and beginning graduate students in mathematics engineering and the physical sciences Preface Part I The Basic Framework for Stationary Problems Chapter 1 Some Model PDEs Chapter 2 The weak form of a BVP Chapter 3 The Galerkin method Chapter 4 Piecewise polynomials and the finite element method Chapter 5 Convergence of the finite element method Part II Data Structures and Implementation Chapter 6 The mesh data structure Chapter 7 Programming the finite element method Linear Lagrange triangles Chapter 8 Lagrange triangles of arbitrary degree Chapter 9 The finite element method for general BVPs Part III Solving the Finite Element Equations Chapter 10 Direct solution of sparse linear systems Chapter 11 Iterative methods Conjugate gradients Chapter 12 The classical stationary iterations Chapter 13 The multigrid method Part IV Adaptive Methods Chapter 14 Adaptive mesh generation Chapter 15 Error estimators and indicators Bibliography Index

Scientific Computing Michael T. Heath,2018-11-14 This book differs from traditional numerical analysis texts in that it focuses on the motivation and ideas behind the algorithms presented rather than on detailed analyses of them It presents a broad overview of methods and software for solving mathematical problems arising in computational modeling and data analysis including proper problem formulation selection of effective solution algorithms and interpretation of results In the 20 years since its original publication the modern fundamental perspective of this book has aged well and it continues to be used in the classroom This Classics edition has been updated to include pointers to Python software and the Chebfun package expansions on barycentric formulation for Lagrange polynomial interpretation and stochastic methods and the availability of about 100 interactive educational modules that dynamically illustrate the concepts and algorithms in the book Scientific Computing An Introductory Survey Second Edition is intended as both a textbook and a reference for computationally oriented disciplines that need to solve mathematical problems *Dubbel* Karl-Heinrich Grote,Jörg Feldhusen,2014-09-30 100 Jahre DUBBEL 1914 erschien die erste Auflage des Taschenbuch f r den Maschinenbau herausgegeben von Heinrich Dubbel Seitdem ist der DUBBEL das Standardwerk der Ingenieure in Studium und Beruf mit den Schwerpunkten Allgemeiner Maschinenbau sowie Verfahrens und Systemtechnik Die laufende Neubearbeitung

garantiert die Dokumentation des aktuellen Stands der Technik Dieses etablierte Referenzwerk mit Norm Charakter berzeugt durch detaillierte Konstruktionszeichnungen Tabellen und Diagramme mit quantitativen Angaben Berechnungsverfahren ein umfangreiches Literaturverzeichnis Der DUBBEL stellt das erforderliche Basis und Detailwissen des Maschinenbaus zur Verf gung F r die Jubil umsauflage wurden alle Kapitel aktualisiert Neu hinzugekommen ist die Medizintechnik die fertigungstechnischen Kapitel wurden stark berarbeitet Auch erhalten die Leser des Werkes Zugang zur MDesign Formelsammlung Die ausf hrliche Darstellung der Mathematik ist als DUBBEL Mathematik separat erh ltlich

Modellreduktion Peter Benner,Heike Faßbender,2024-03-20 Dieses Lehrbuch f hrt konsequent algorithmisch orientiert in die Modellreduktion linearer zeitinvarianter Systeme ein der Fokus liegt hierbei auf systemtheoretischen Methoden Insbesondere werden modales und balanciertes Abschneiden eingehend behandelt Dar ber hinaus werden Methoden des Momentenabgleichs basierend auf Krylovraumverfahren und rationaler Interpolation diskutiert Dabei werden alle notwendigen Grundlagen sowohl aus der Systemtheorie als auch aus der numerischen linearen Algebra vorgestellt Die Illustration der in diesem Buch vorgestellten Verfahren der Modellreduktion sowie einiger der notwendigen verwendeten Konzepte aus unterschiedlichen mathematischen Bereichen erfolgt anhand einer Reihe von numerischen Beispielen Dazu werden die mathematische Software MATLAB und einige frei verf gbare Software Pakete eingesetzt so dass alle Beispiele nachvollzogen werden k nnen **Wissenschaftliches Rechnen** Gilbert Strang,2010-06-01 Eine wesentliche Notwendigkeit f r heutige Studenten und Leser besteht darin von den herk mmlichen formelbasierten Kursen abzukommen und zu rechnergest tzten Kursen berzugehen Das Ziel dieses jetzt auch endlich in deutscher Version erh ltlichen Buches ist es sowohl angewandte Mathematik als auch Ingenieurmathematik so darzustellen wie sie heutzutage tats chlich Anwendung finden Dieses Buch entstand aus dem Kurs zu wissenschaftlichem Rechnen der seit 20 Jahren am Massachusetts Institute of Technology abgehalten wird Das Buch versucht Konzepte und Algorithmen f r den Leser zusammenzuf hren Die Autoren beginnen mit der angewandten linearen Algebra einem bei vielen Lesern zu kurz gekommenen Gebiet welches aber ein wesentliches Werkzeug f r das wissenschaftliche Rechnen und seine Anwendungen ist Anschlie end entwickeln sie die Methoden der finiten Differenzen und finiten Elemente stets mit Hinblick auf die angewandte Mathematik um dieses Gebiet mit Anwendungen in zahlreichen Wissensgebieten in Verbindung zu bringen Studenten Dozenten und Forscher werden dieses Buch gleicherma en mit gro em Gewinn lesen **Parallel Numerical Algorithms** David E. Keyes,Ahmed Sameh,V. Venkatakrishnan,2012-12-06 In this volume designed for computational scientists and engineers working on applications requiring the memories and processing rates of large scale parallelism leading algorithmicists survey their own field defining contributions together with enough historical and bibliographical perspective to permit working one s way to the frontiers This book is distinguished from earlier surveys in parallel numerical algorithms by its extension of coverage beyond core linear algebraic methods into tools more directly associated with partial differential and integral equations though still with

an appealing generality and by its focus on practical medium granularity parallelism approachable through traditional programming languages Several of the authors used their invitation to participate as a chance to stand back and create a unified overview which nonspecialists will appreciate *Computational Methods in Power System Analysis* Reijer Idema,Domenico J.P. Lahaye,2014-07-08 This book treats state of the art computational methods for power flow studies and contingency analysis In the first part the authors present the relevant computational methods and mathematical concepts In the second part power flow and contingency analysis are treated Furthermore traditional methods to solve such problems are compared to modern solvers developed using the knowledge of the first part of the book Finally these solvers are analyzed both theoretically and experimentally clearly showing the benefits of the modern approach *Matrix Computations* Gene H. Golub,Charles F. Van Loan,2013-02-15 A comprehensive treatment of numerical linear algebra from the standpoint of both theory and practice The fourth edition of Gene H Golub and Charles F Van Loan s classic is an essential reference for computational scientists and engineers in addition to researchers in the numerical linear algebra community Anyone whose work requires the solution to a matrix problem and an appreciation of its mathematical properties will find this book to be an indispensible tool This revision is a cover to cover expansion and renovation of the third edition It now includes an introduction to tensor computations and brand new sections on fast transforms parallel LU discrete Poisson solvers pseudospectra structured linear equation problems structured eigenvalue problems large scale SVD methods polynomial eigenvalue problems Matrix Computations is packed with challenging problems insightful derivations and pointers to the literature everything needed to become a matrix savvy developer of numerical methods and software The second most cited math book of 2012 according to MathSciNet the book has placed in the top 10 for since 2005 Parallel and Distributed Processing and Applications Minyi Guo,2006-11-27 This book constitutes the refereed proceedings of the 4th International Symposium on Parallel and Distributed Processing and Applications ISPA 2006 held in Sorrento Italy in November 2006 The 79 revised full papers presented together with five keynote speeches cover architectures networks languages algorithms middleware cooperative computing software and applications *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 **Parallel Processing for Scientific Computing** Michael A. Heroux,Padma Raghavan,Horst D. Simon,2006-01-01 Scientific computing has often been

called the third approach to scientific discovery emerging as a peer to experimentation and theory Historically the synergy between experimentation and theory has been well understood experiments give insight into possible theories theories inspire experiments experiments reinforce or invalidate theories and so on As scientific computing has evolved to produce results that meet or exceed the quality of experimental and theoretical results it has become indispensable Parallel processing has been an enabling technology in scientific computing for more than 20 years This book is the first in depth discussion of parallel computing in 10 years it reflects the mix of topics that mathematicians computer scientists and computational scientists focus on to make parallel processing effective for scientific problems Presently the impact of parallel processing on scientific computing varies greatly across disciplines but it plays a vital role in most problem domains and is absolutely essential in many of them Parallel Processing for Scientific Computing is divided into four parts The first concerns performance modeling analysis and optimization the second focuses on parallel algorithms and software for an array of problems common to many modeling and simulation applications the third emphasizes tools and environments that can ease and enhance the process of application development and the fourth provides a sampling of applications that require parallel computing for scaling to solve larger and realistic models that can advance science and engineering This edited volume serves as an up to date reference for researchers and application developers on the state of the art in scientific computing It also serves as an excellent overview and introduction especially for graduate and senior level undergraduate students interested in computational modeling and simulation and related computer science and applied mathematics aspects Contents List of Figures List of Tables Preface Chapter 1 Frontiers of Scientific Computing An Overview Part I Performance Modeling Analysis and Optimization Chapter 2 Performance Analysis From Art to Science Chapter 3 Approaches to Architecture Aware Parallel Scientific Computation Chapter 4 Achieving High Performance on the BlueGene L Supercomputer Chapter 5 Performance Evaluation and Modeling of Ultra Scale Systems Part II Parallel Algorithms and Enabling Technologies Chapter 6 Partitioning and Load Balancing Chapter 7 Combinatorial Parallel and Scientific Computing Chapter 8 Parallel Adaptive Mesh Refinement Chapter 9 Parallel Sparse Solvers Preconditioners and Their Applications Chapter 10 A Survey of Parallelization Techniques for Multigrid Solvers Chapter 11 Fault Tolerance in Large Scale Scientific Computing Part III Tools and Frameworks for Parallel Applications Chapter 12 Parallel Tools and Environments A Survey Chapter 13 Parallel Linear Algebra Software Chapter 14 High Performance Component Software Systems Chapter 15 Integrating Component Based Scientific Computing Software Part IV Applications of Parallel Computing Chapter 16 Parallel Algorithms for PDE Constrained Optimization Chapter 17 Massively Parallel Mixed Integer Programming Chapter 18 Parallel Methods and Software for Multicomponent Simulations Chapter 19 Parallel Computational Biology Chapter 20 Opportunities and Challenges for Parallel Computing in Science and Engineering Index High-Performance Scientific Computing Michael W. Berry,Kyle A. Gallivan,Efstratios Gallopoulos,Ananth Grama,Bernard Philippe,Yousef Saad,Faisal

Saied,2012-01-18 This book presents the state of the art in parallel numerical algorithms applications architectures and system software The book examines various solutions for issues of concurrency scale energy efficiency and programmability which are discussed in the context of a diverse range of applications Features includes contributions from an international selection of world class authorities examines parallel algorithm architecture interaction through issues of computational capacity based codesign and automatic restructuring of programs using compilation techniques reviews emerging applications of numerical methods in information retrieval and data mining discusses the latest issues in dense and sparse matrix computations for modern high performance systems multicores manycores and GPUs and several perspectives on the Spike family of algorithms for solving linear systems presents outstanding challenges and developing technologies and puts these in their historical context

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