Direct Methods for Sparse Linear Systems

Timothy A. Davis

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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 Joseph M. Elble,2007   *Direct Methods for the Solution of Sparse Linear Systems of Equations* Sonya Faith Stephenson,1988   *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 **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 **Graph Database and Graph Computing for Power System Analysis** Renchang Dai,Guangyi Liu,2023-09-28 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 **Solving Linear Systems on Vector and Shared Memory Computers** J. J. Dongarra,1991 Mathematics of Computing

Parallelism   An Efficient Direct Method of Solving Sparse Linear Systems National University of Singapore. Dept. of Information Systems and Computer Science,Kang Hoh Phua,1988   *Direct Methods for Sparse Matrices* O. Osterby,Z. Zlatev,1983-08   **Algorithms for Sparse Linear Systems** Jennifer Scott,Miroslav Tůma,2023-04-29 Large sparse linear systems of equations are ubiquitous in science engineering and beyond This open access monograph focuses on factorization algorithms for solving such systems It presents classical techniques for complete factorizations that are used in sparse direct methods and discusses the computation of approximate direct and inverse factorizations that are key to constructing general purpose algebraic preconditioners for iterative solvers A unified framework is used that emphasizes the underlying sparsity structures and highlights the importance of understanding sparse direct methods when developing algebraic preconditioners Theoretical results are complemented by sparse matrix algorithm outlines This monograph is aimed at students of applied mathematics and scientific computing as well as computational scientists and software developers who are interested in understanding the theory and algorithms needed to tackle sparse systems It is assumed that the reader has completed a basic course in linear algebra and numerical mathematics   **SIAM Journal on Scientific Computing** ,2004

   Encyclopedia of Parallel Computing David Padua,2011-09-08 Containing over 300 entries in an A Z format the Encyclopedia of Parallel Computing provides easy intuitive access to relevant information for professionals and researchers seeking access to any aspect within the broad field of parallel computing Topics for this comprehensive reference were selected written and peer reviewed by an international pool of distinguished researchers in the field The Encyclopedia is broad in scope covering machine organization programming languages algorithms and applications Within each area concepts designs and specific implementations are presented The highly structured essays in this work comprise synonyms a definition and discussion of the topic bibliographies and links to related literature Extensive cross references to other entries within the Encyclopedia support efficient user friendly searchers for immediate access to useful information Key concepts presented in the Encyclopedia of Parallel Computing include laws and metrics specific numerical and non numerical algorithms asynchronous algorithms libraries of subroutines benchmark suites applications sequential consistency and cache coherency machine classes such as clusters shared memory multiprocessors special purpose machines and dataflow machines specific machines such as Cray supercomputers IBM s cell processor and Intel s multicore machines race detection and auto parallelization parallel programming languages synchronization primitives collective operations message passing libraries checkpointing and operating systems Topics covered Speedup Efficiency Isoefficiency Redundancy Amdahls law Computer Architecture Concepts Parallel Machine Designs Benmarks Parallel Programming concepts design Algorithms Parallel applications This authoritative reference will be published in two formats print and online The online edition features hyperlinks to cross references and to additional significant research Related Subjects supercomputing high performance computing distributed computing   Proceedings of the Thirty-ninth Annual ACM Symposium on Theory of Computing ACM

Special Interest Group for Algorithms and Computation Theory,2007   Handbook of Numerical Analysis Philippe G. Ciarlet,Jacques-Louis Lions,1990 These volumes cover all the major aspects of numerical analysis This particular volume discusses the solution of equations in Rn Gaussian elimination techniques of scientific computer the analysis of multigrid methods wavelet methods and finite volume methods   **Proceedings of the ...ACM Symposium on Theory of Computing** ,2007   *Proceedings of the 1990 International Conference on Parallel Processing* Benjamin W. Wah,David A. Padua,Pen-Chung Yew,Pennsylvania State University,1990   *Memoirs of the Scientific Sections of the Academy of the Socialist Republic of Romania* ,2004   **HERMIS '94** ,1994   Bridging the Gap Between H-Matrices and Sparse Direct Methods for the Solution of Large Linear Systems Aurélien Falco,2019 Many physical phenomena may be studied through modeling and numerical simulations commonplace in scientific applications To be tractable on a computer appropriated discretization techniques must be considered which often lead to a set of linear equations whose features depend on the discretization techniques Among them the Finite Element Method usually leads to sparse linear systems whereas the Boundary Element Method leads to dense linear systems The size of the resulting linear systems depends on the domain where the studied physical phenomenon develops and tends to become larger and larger as the performance of the computer facilities increases For the sake of numerical robustness the solution techniques based on the factorization of the matrix associated with the linear system are the methods of choice when affordable In that respect hierarchical methods based on low rank compression have allowed a drastic reduction of the computational requirements for the solution of dense linear systems over the last two decades For sparse linear systems their application remains a challenge which has been studied by both the community of hierarchical matrices and the community of sparse matrices On the one hand the first step taken by the community of hierarchical matrices most often takes advantage of the sparsity of the problem through the use of nested dissection While this approach benefits from the hierarchical structure it is not however as efficient as sparse solvers regarding the exploitation of zeros and the structural separation of zeros from non zeros On the other hand sparse factorization is organized so as to lead to a sequence of smaller dense operations enticing sparse solvers to use this property and exploit compression techniques from hierarchical methods in order to reduce the computational cost of these elementary operations Nonetheless the globally hierarchical structure may be lost if the compression of hierarchical methods is used only locally on dense submatrices We here review the main techniques that have been employed by both those communities trying to highlight their common properties and their respective limits with a special emphasis on studies that have aimed to bridge the gap between them With these observations in mind we propose a class of hierarchical algorithms based on the symbolic analysis of the structure of the factors of a sparse matrix These algorithms rely on a symbolic information to cluster and construct a hierarchical structure coherent with the non zero pattern of the matrix Moreover the resulting hierarchical matrix relies on low rank compression for the reduction of the memory consumption of large submatrices as well as the time

to solution of the solver We also compare multiple ordering techniques based on geometrical or topological properties Finally we open the discussion to a coupling between the Finite Element Method and the Boundary Element Method in a unified computational framework   *Introduction to Parallel Computing* Vipin Kumar,1994 Mathematics of Computing Parallelism

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Direct Methods For Sparse Linear Systems Introduction

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