

A New Subspace Iteration Algorithm for Solving Generalized Eigenvalue Problems

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Abstract

It is needed to solve generalized eigenvalue problems (GEP) in many applications, such as the numerical simulation of vibration analysis, quantum mechanics, electronic structure, etc. The subspace iteration is a kind of widely used algorithm to solve eigenvalue problems. To solve the generalized eigenvalue problem, one kind of subspace iteration method, Chebyshev-Davidson algorithm, is proposed recently. In Chebyshev-Davidson algorithm, the Chebyshev polynomial filter technique is incorporated in the subspace iteration [15]. In this paper, based on Chebyshev-Davidson algorithm, a new subspace iteration algorithm is constructed. In the new algorithm, the Chebyshev filter and inexact Rayleigh quotient iteration techniques are combined together to enlarge the subspace in the iteration. Numerical results of a vibration analysis problem show that the number of iteration and computing time of the proposed algorithm is much less than that of the Chebyshev-Davidson algorithm and some typical GEP solution algorithms. Furthermore, the new algorithm is more stable and reliable than the Chebyshev-Davidson algorithm in the numerical results.

Keywords: Generalized eigenvalue problem, Davidson algorithm, Chebyshev filter, Rayleigh quotient iteration, Acceleration

Mathematics Subject Classification (2010): 65F15, 65N25, 65H17

1 Introduction

Consider the following symmetric generalized eigenvalue problem (GEP)

$$\mathbf{A}\mathbf{x} = \lambda\mathbf{B}\mathbf{x}, \quad \text{with} \quad \|\mathbf{x}\|_{\mathbf{B}} = 1, \quad (1)$$

where $\mathbf{A} \in \mathbb{R}^{N \times N}$ and $\mathbf{B} \in \mathbb{R}^{N \times N}$ are large, sparse and symmetric matrices with $\mathbf{B}$ being positive definite, $\|\mathbf{x}\|_{\mathbf{B}}$ is the $\mathbf{B}$ -norm of the vector $\mathbf{x}$ which will be defined later. In many applications, it is needed to solve GEP (1), such as the vibration analysis, quantum mechanics, electronic structure calculations, etc. In (1), the matrix $\mathbf{A}$ is the stiffness matrix, and $\mathbf{B}$ represents the mass matrix. λ is an eigenvalue of the matrix pencil $(\mathbf{A}, \mathbf{B})$, and the nonzero vector $\mathbf{x}$ is the corresponding eigenvector. $(\lambda, \mathbf{x})$ is called an eigenpair of GEP. If $\mathbf{B}$ is a diagonal matrix, then the generalized eigenvalue problem reduces to the standard eigenvalue problem (SEP). Usually, the smallest eigenvalues and the corresponding eigenvectors play more important role in real applications than the largest ones. We are interested in the computation for the smallest eigenvalues and corresponding eigenvectors of a large sparse eigenvalue problem in this paper.

By now, many algorithms have been developed for solving eigenvalue problems [6, 25, 29]. These algorithms can be divided roughly into two classes: the direct methods and iterative methods. For large

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And Advanced Applications: 3rd European Conf, Jul 99, Finland Pekka Neittaanmaki,Pasi Tarvainen,Timo

Tiihonen,2000-09-05 This volume contains major lectures given at ENUMATH 99 the 3rd European Conference on Numerical Mathematics and Advanced Applications The ENUMATH conferences were established in 1995 to provide a forum for discussing current topics in numerical mathematics They convene leading experts and young scientists with special emphasis on contributions from Europe Recent results and new trends are discussed in the analysis of numerical algorithms as well as their application to challenging scientific and industrial problems The topics of ENUMATH 99 included finite element methods a posteriori error control and adaptive mesh design non matching grids least squares methods for partial

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Lanczos Algorithms for Large Symmetric Eigenvalue Computations Jane K. Cullum, Ralph A. Willoughby, 2002-09-01 First published in 1985 this book presents background material descriptions and supporting theory relating to practical numerical algorithms for the solution of huge eigenvalue problems This book deals with symmetric problems However in this book symmetric also encompasses numerical procedures for computing singular values and vectors of real rectangular matrices and numerical procedures for computing eigenelements of nondefective complex symmetric matrices Although preserving orthogonality has been the golden rule in linear algebra most of the algorithms in this book conform to that rule only locally resulting in markedly reduced memory requirements Additionally most of the algorithms discussed separate the eigenvalue singular value computations from the corresponding eigenvector singular vector computations This separation prevents losses in accuracy that can occur in methods which in order to be able to compute further into the spectrum use successive implicit deflation by computed eigenvector or singular vector approximations

Multigrid Finite Element Methods for Electromagnetic Field Modeling Yu Zhu, Andreas C. Cangellaris, 2006-02-17 This is the first comprehensive monograph that features state of the art multigrid methods for enhancing the modeling versatility numerical robustness and computational efficiency of one of the most popular classes of numerical electromagnetic field modeling methods the method of finite elements The focus of the publication is the development of robust preconditioners for the iterative solution of electromagnetic field boundary value problems BVPs discretized by means of finite methods Specifically the authors set forth their own successful attempts to utilize concepts from multigrid and multilevel methods for the effective preconditioning of matrices resulting from the approximation of electromagnetic BVPs using finite methods Following the authors careful explanations and step by step instruction readers can duplicate the authors results and take advantage of today's state of the art multigrid multilevel preconditioners for finite element based iterative electromagnetic field solvers Among the highlights of coverage are Application of multigrid multilevel and hybrid multigrid multilevel preconditioners to electromagnetic scattering and radiation problems Broadband robust numerical modeling of passive microwave components and circuits Robust finite element based modal analysis of electromagnetic waveguides and cavities Application of Krylov subspace based methodologies for reduced order macromodeling of electromagnetic devices and systems Finite element modeling of electromagnetic waves in periodic structures The authors provide more than thirty detailed algorithms alongside pseudo codes to assist readers with practical computer implementation In addition each chapter includes an applications section with helpful numerical examples that validate the authors methodologies and demonstrate their computational efficiency and robustness This groundbreaking book with its coverage of an exciting new enabling computer aided design technology is an

essential reference for computer programmers designers and engineers as well as graduate students in engineering and applied physics

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Stochastic Analysis of Offshore Steel Structures Halil Karadeniz,2012-08-01 Stochastic Analysis of Offshore Steel Structures provides a clear and detailed guide to advanced analysis methods of fixed offshore steel structures using 3D beam finite elements under random wave and earthquake loadings Advanced and up to date research results are coupled with modern analysis methods and essential theoretical information to consider optimal solutions to structural issues As these methods require and use knowledge of different subject matters a general introduction to the key areas is provided This is followed by in depth explanations supported by design examples relevant calculations and supplementary material containing related computer programmers By combining this theoretical and practical approach Stochastic Analysis of Offshore Steel Structures cover a range of key concepts in detail including The basic principles of standard 3D beam finite elements and special connections Wave loading from hydrodynamics to the calculation of wave loading on structural members Stochastic response calculations with corresponding solution algorithms including earthquakes and Fatigue damage reliability calculation and reliability based design optimization The broad and detailed coverage makes this a solid reference for research oriented studies and practical sophisticated design methods Students researchers insuring bodies and practical designer offices can turn to Stochastic Analysis of Offshore Steel Structures to broaden their theoretical understanding and develop their practical designs and applications of 3D finite analysis in fixed offshore steel structures

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the ballroom hello would you like to dance cinderella

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web girls don t forget to give cinderella your laundry it s dirty sock day the stepsisters dump a pile of dirty socks on cinderella s head and exit the mice clench their paws in anger

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web cinderella looks at her torn dress stepmother sneers at cinderella goodnight cinderella stepmother and the stepsisters exit cinderella collapses to the ground

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web cinderella had an evil stepmother and two evil stepsisters named anastasia and drizella narrator 4 cold cruel and jealous they made cinderella a servant in her own house

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web voila finally the cinderella story script is here for all you quotes spouting fans of the movie starring hiliary duff this script is a transcript that was painstakingly transcribed using the screenplay and or viewings of cinderella story i know i know i still need to get the cast names in there and i ll be eternally tweaking it so if you have any corrections feel

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web script print audition central disney s cinderella kids script other mice side 1 narrator 3 not everyone in the house hated cinderella mice scurry on and crowd around cinderella mice cinderelly cinderelly cinderelly cinderelly narrator 3 the mice were her best friends and helped her as much as they could