Preface

Problems of numerical linear algebra arise in all fields of modern science. Important examples are computational fluid dynamics, solid mechanics, electrical networks, signal analysis, and optimization. In our book we present an extended basic theory of linear algebra including such topics as matrix algebra, theory of linear systems of equations, spectral theory, vector and matrix norms, combined with the most important direct and iterative numerical methods for solution of linear systems of equations, least squares problems, and eigenproblems. In this book we wanted to combine a solid theoretical background in linear algebra with practical algorithms for numerical solution of linear algebra problems. Most of the presented numerical algorithms are illustrated by computer programs written in MATLAB®, which are given in the electronic supplementary material that can be found on SpringerLink. These programs allow the reader to obtain experience in implementation and evaluation of numerical algorithms for the problems described in the book and give possibility to apply them to the solution of the computer exercises presented in this book. They can also give the reader a better understanding of professional numerical software for the solution of real-life problems in numerical linear algebra.

This book is suitable for use as course material in a one- or two-semester course on numerical linear algebra, matrix computations, or large sparse matrices at the advanced undergraduate or graduate level. We recommend using the material of Chapters 1–7 for courses in the theoretical aspects of linear algebra, or as the first part for a course in numerical linear algebra. In addition to traditional content for courses in linear algebra for students specializing in the physical and mathematical sciences, we include in these chapters some sections that can be useful as course material for special courses on various applications of linear algebra. We hope that this material will also be of interest to scientists. We recommend Chapters 8–12 for courses related to numerical linear algebra, or as the second part of a course in numerical linear algebra. The material of Chapters 8–12 follows the book of Demmel [23]. Compared with [23], we present the numerical material of Chapters 8–12 in a more concise form, which is appropriate to a one-semester course in numerical linear algebra at the undergraduate level. We also enrich our Chapters 8–12 with numerical examples, which can be tested by the MATLAB® and PETSc programs are available in the electronic supplementary material that can be found on SpringerLink.

In the first four chapters we introduce readers to the topic of linear algebra and give the main definitions of complex numbers and polynomials, systems of linear equations, matrices, determinants, vector and inner product spaces, subspaces, linear operators, and eigenvalues and eigenvectors of a linear operator. In Chapter 5 we present canonical forms and factorizations: the singular value decomposition, the Jordan canonical form, matrix pencils and Weierstrass canonical form, the Kronecker canonical form, and their applications in the theory of ordinary differential equations. Chapter 6 discusses vector and matrix norms and Chapter 7 presents the main elements of perturbation theory for basic problems of linear algebra. Chapters 8–11 deal with numerical solution of systems of linear equations, linear least squares problems, and the solution of eigenvalue problems. In Chapter 12 we give a brief introduction to the main iterative methods for the solution of linear systems: Jacobi, Gauss–Seidel, and Successive overrelaxation. We also discuss Krylov subspace methods, the conjugate gradient algorithm, and the preconditioned conjugate gradient algorithm. Compared with other books on the same subject, this book presents a combination of extended material on the rigorous theory of linear algebra together with numerical aspects and implementation of algorithms of linear algebra in MATLAB®. The material of this book was developed from a number of courses which the authors taught repeatedly for a long period at the master's program in engineering mathematics and computational science at Chalmers University of Technology and University of Gothenburg, Sweden, and at Institute of Computational Mathematics and Information Technologies of Kazan Federal University, Russia. Chapters 1–7 were written by Mikhail and Evgenii Karchevskii. Larisa Beilina wrote Chapters 8–12 and the electronic supplementary material that can be found on SpringerLink.

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