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Book Review

The Lanczos Method: Evolution and Application, by Louis Komzsik, Society for Industrial and Applied Mathematics, Philadelphia, PA, USA, 2003. ISBN: 0 89871 537 7

Louis Komzsik is an expert on structural analysis who has worked for 20 years as the chief numerical analyst at MSC Software. He was responsible for the numerical methods in the NASTRAN finite element solver. This book is an introduction to the Lanczos method and its applications in finite element analysis. The Lanczos method has obviously been very important in Kmozsik's work on NASTRAN. The book is also a homage to Kmozsik's Hungarian countryman Cornelius Lanczos.

The first half of the book is a brief (33 pages) introduction to the Lanczos method. In Chapter one, Komzsik begins with a discussion of the connection between the eigenvalues of a symmetric matrix A and the ellipsoid given by the equation $xTAx = 1$. This section is marred by a serious misstatement of the relationship between A's eigenvalues and the lengths of the axes of the ellipsoid. The author continues by giving a fairly standard derivation of the Lanczos iteration as a way to compute the characteristic polynomial of a symmetric matrix.

The method is extended to unsymmetric matrices and then to the computation of a tridiagonal matrix T that is similar to A. In Chapter 2, the author discusses how the eigenvalues and eigenvectors of T can be obtained. In Chapter 3 a version of the algorithm for finite precision arithmetic is developed. In fi- nite precision, loss of orthogonality of the Lanczos vectors is a serious problem. Komzsik discusses the full orthogonalization strategy for recovering from this loss of orthogonality. Block methods for symmetric and unsymmetric matrices are introduced in Chapters four and five.

The presentation is made unnecessarily complicated by several changes in notation. The discussion of reorthogonalization strategies other than full orthogonalization is particularly brief. The lack of any discussion of the Arnoldi iteration is notable. There is also no discussion of available software that implements the Lanczos method. The introduction to the Lanczos method in the first half of the book contains standard material that is already present in many textbooks on numerical linear algebra [2,3,5]. Given the lack of exercises in this book, most students would be better served by reading about the Lanczos iteration in one of the standard textbooks.

The second half of the book discusses applications of the Lanczos method in finite element analysis. In Chapter six, the spectral transformation is intro- duced as a way to spread out closely spaced eigenvalues. The author discusses frequency domain decomposition and geometric domain decomposition as ways to parallelize the computation of the eigenvalues of large matrices arising from finite element analysis. Applications of the Lanczos method to free undamped vibrations, free damped vibrations, and forced vibrations are the subject of chapters seven through nine. Examples of the application of these approaches to engineering design problems are given. In Chapter ten, the method of conjugate gradients is derived as an application of the Lanczos iteration.

The discussion of applications of the Lanczos iteration to finite element analysis is the most interesting aspect of the book. This half of the book might be of interest to mathematicians who are comfortable with numerical linear algebra but not familiar with finite element analysis. However, these chapters would be much more interesting if readers could actually tinker with the data sets and software. Furthermore, the application of the Lanczos method to structural analysis problems is commonly covered in textbooks on finite element analysis [1,4].

References

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