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Uri Kirsch: Design-oriented analysis of structures. Kluwer Academic Publishers, Dordrecht, 2002. p. 236

Professor Kirsch has been developing structural reanalysis and approximate analysis techniques for over three decades. Over the last decade he has refined his so-called combined approximation (CA), a reduced basis method that employs base vectors generated by the binomial series. The CA has proved to be able to provide accurate approximations even for large changes in size, geometry, and topology, and this reviewer has used it to great benefit for large-scale wing-design problems. This book provides the reader with a general background on reanalysis and approximations with the CA at center stage.

The book is divided into two parts. Part 1, titled "Concepts and Methods" provides the general background. Part 2, titled "A Unified Approach" introduces the CA and presents applications and generalizations.

Part 1 has six chapters. Chapter 1, Introduction, presents the basic concepts of structural analysis, design variables, structural changes, and reanalysis, as well as a roadmap to the rest of the textbook. Chapter 2, Structural Analysis, provides a brief overview of finite element static linear analysis, nonlinear analysis, and vibrational and buckling eigenanalysis. Chapter 3, Reanalysis of Structures, defines the equations that need to be solved in reanalysis and classifies methods for exact reanalysis (direct methods) and approximations.

Chapter 4, Direct Methods, presents the Sherman–Morrison–Woodbury (SMW) procedure for exact reanalysis of linear equations to account for a low-rank change in the matrix of the equations. Section 4.3 also presents a method by Argyris and Roy from 1972, which is sometimes easier to implement than SMW. However, it has been shown to be inefficient.

Chapter 5, Local Approximations, presents Taylor series approximations, the binomial series approximation, as well as intermediate variables and response variables. Also featured in detail is the use of scaling, a topic which is sadly neglected in many textbooks. Chapter 6, Global Approximations, briefly introduces response surface approximations, the reduced basis technique, and the preconditioned conjugate gradient approximation.

With these basics introduced, Part 2 opens with Chapter 7, Combined Approximations, introducing the CA for linear static analysis. The CA is shown to be equivalent to the preconditioned conjugate gradient method when the preconditioner is a Cholesky factor of the stiffness matrix. Results are presented for several truss structures. Chapter 8, Simplified Solution Techniques, compares the CA with its simpler predecessors, the binomial and scaled approximations. The efficiency of the CA compared with full reanalysis is presented through for a dense stiffness matrix. Finally it is shown that the CA is equivalent to the SMW formulas for a change in a single truss element, with a proper choice of base vectors for changes in several elements.

Chapter 9, Topological and Geometrical Changes, presents the CA for member addition and deletion. In addition, many truss examples demonstrate good accuracy for modified geometries and topologies. Chapter 10, Design Sensitivity Analysis, deals with derivative calculations. Both first and higher order derivatives are demonstrated for an example of a 10-bar truss.

Chapter 11, Nonlinear Reanalysis, deals with geometrically nonlinear analysis and reanalysis. First it is shown that the CA can be used instead of Newton's method or in Newton's method for nonlinear analysis. Then the process is generalized to reanalysis.

Chapter 12, Vibration Reanalysis, describes the use of CA for approximating the vibrational modes and frequencies of modified structures. A different set of basis vectors is used for each mode. It is possible that the approach can be improved in some cases by combining the basis vectors.

The textbook is easy to read and is full of detailed examples. It should be very useful to students and practitioners interested in structural approximation techniques.

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