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BOOK REVIEW

APPLIED CFD TECHNIQUES: AN INTRODUCTION BASED ON FINITE ELEMENT METHODS. by R. Löhner, John Wiley & Sons, Chichester 2001, Number of pages: 376. ISBN 0-471-49843-2. Price: $95.00.

There are a wide variety of books available on finite element methods, ranging from introductory teaching texts to advanced treatises for practitioners and graduate and continuing education. Most of these books focus on the application of the method to a particular class of boundary value problem and dwell on equation formulations, finite element types and interpolation functions, linear and nonlinear solution methods and time integration procedures. The book by Professor Löhner is a decidedly different type of finite element book in that it concentrates on the actual computer implementation of the method with a strong focus on computational efficiency. Though the methods and algorithms presented are developed in the context of computational fluid dynamics (CFD), many of the strategies covered in the book would be useful across the finite element applications landscape. The book is labelled as an introduction though it becomes clear very quickly that a fair amount of experience in CFD is needed to appreciate why and how the author is proceeding through the material.

The introduction provides the author's philosophy regarding CFD, code development and efficiency and sets the tone for the remainder of the book. The opening also reflects the author's long involvement and expertise in writing "production" code and using CFD for complex industrial applications. The second chapter plunges into data structures and algorithms for data entities that are needed in both rudimentary and advanced element based codes. Code fragments and algorithmic outlines are provided in the text. Many of these procedures have probably been developed and re-developed by individual code writers though not with the efficiency or forethought provided here. Mesh generation methods are covered next, with a good introduction to meshing difficulties and the general methods for grid construction. The advancing front and Delaunay triangulation algorithms are covered in substantial detail, with shorter sections on grid improvement and grid generation for Reynolds Averaged Navier–Stokes applications.

The next four chapters cover topics that would be found in most standard finite element books, though the treatment is from a somewhat different perspective. The chapter on approximation theory is simple, but well done and very understandable, unlike many texts. Likewise the chapter on approximation of operators is quite good, though this discussion may be too sparse for any but the well-versed finite element practitioner. Chapter 6 outlines, very briefly, time integration methods. The chapter on solution of large linear systems of equations provides a quick review of direct solution methods and a longer discussion of iterative solvers and multigrid methods.

Chapters 8 through 11 concentrate on flow solvers and in particular, methods for the compressible Euler and Navier–Stokes equations. The compressible flow regime has been the author's main research area and his expertise and experience in this regime is clear in these chapters. A catalog of discretization and artificial viscosity methods is provided and is followed by a short introduction to the use of flux corrected transport methods in a finite element context. The interesting and somewhat different topic of edge based data structures for flow solvers is covered in Chapter 10. This material requires serious study if it is to be utilized effectively. The last chapter in this sequence covers incompressible flow solvers and is really just a sketch of the main issues associated with this class of problem. Chapter 16 could really be included in this sequence as it covers space marching techniques, a specialized but effective method primarily for supersonic flows.

Advanced methods associated with mesh movement and adaptivity are discussed in the next three chapters. Mesh movement and smoothing are covered in Chapter 12 as well as a description of the geometric conservation law and when it is a required part of the overall algorithm. Interpolation of data from one mesh to another is outlined in the next chapter along with significant discussion of effective methods for node searches within a mesh. A good summary of error indicators for use in adaptive mesh strategies forms the first part of Chapter 14. The chapter is concluded with a tutorial on remeshing with tetrahedral elements, the finite element favored by the author. Chapter 15 is a broad discussion of issues stemming from developments in computer hardware including memory distributions, vector processors, multiprocessor machines and load balancing. The material has a decided computer science flavor but is really necessary for modern flow code development and implementation.

This is a very good text and would be a useful addition to the library of CFD practitioners and code developers. Unlike many first editions, relatively few typographical or other errors could be found. The presentation is clear and concise, the code fragments and pseudo-code are very helpful and the flow examples quite impressive. It is not the type of text from which a beginner could learn CFD. It is a text for someone who wants to learn how to structure data, implement algorithms and install advanced procedures, like adaptivity, and make CFD a useful and powerful engineering tool.

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