Book Review

Automatic Mesh Generation: Application to Finite Elements Method, by P. L. George. Published by John Wiley & Sons, Inc., New York, 1991. $99.95, 333 pp.

The first step in a finite element calculation is determination of a computational mesh, that is, the reduction of a real domain with a regular or irregular boundary having infinite degrees of freedom to a computational simulant with a finite system of nodes and elements at which the solution will be determined and that, in the limit, should exhibit the characteristics of the original domain when subjected to given boundary and initial conditions. In practice, this is a critical and time-consuming step. The quality of the numerical solution is strongly related to the quality of the mesh. Furthermore, only about 20% of an engineer's time is spent on computations. The remaining 80% is spent in determining and refining the computational mesh and interpreting computational results. Hence, the better the preprocessor (mesh generator) and postprocessor (display capability) of a given finite element program in terms of capability, generality, and user friendliness, the more efficient the use of an engineer's time and the lower the project cost.

This is a very good introductory book for someone completely new to mesh generation techniques for finite element calculations. The first two chapters are concerned with basic definitions. In addition, mesh generation schemes are assigned to seven categories:

1. brute force specification of nodes and elements;
2. mapping meshes between real and reference domains;
3. deriving meshes through solution of partial differential equations;
4. quadtree and octree methods: enclosing the domain in a quadrilateral or quadrilateral parallelepipedon that is split into boxes. These boxes are constructed by decomposition based on a quarternary tree (two dimensions) or octal tree (three dimensions). This grid is then used to create the desired mesh.
5. block decomposition methods: discretization of the domain roughly by a set of blocks of elementary shape, then using the techniques of 2 and 3 above to refine the mesh;
6. advancing front methods and algorithms based on Voronoi–Delaunay construction; and
7. splitting the mesh generation into a set of subproblems, development of submeshes by any of methods 1–6, then transformation and pasting together of the submeshes into a complete mesh.

Subsequent chapters then discuss each of these approaches in turn, giving the basic algorithms and examples of their applications. Additional chapters briefly discuss various mesh generation packages popular in Europe. An extensive bibliography is provided.

The discussion of each of the mesh generation methodologies is lucid and in sufficient detail to make the procedure conceptually clear. However, each chapter is quite short (the book is only 333 pages) and lacks the detail necessary to go from understanding of the concept to its practical application. It would not be possible for an engineer to go from reading the appropriate chapter in this book to developing a mesh generator for

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even simple geometries as might be found in codes such as ALGOR, ADINA, DYNA, NIKE, EPIC, CTH, or ZeuS, to name but a few. However, it is invaluable in helping a novice understand how such mesh generators work.

There is periodic reference in the book to the finite element Modulef code for mesh generation and manipulation that is used at the author's facility. The book would have been much stronger if specific portions of this library had been included as appendices to the various chapters so the reader could go from a discussion of concepts through the relevant algorithms to a direct application of these algorithms in a computer code. Merely citing Modulef or, for that matter, any mesh generator, limits the utility of the book and frustrates the reader because he or she is unlikely to be able to obtain the package or have any need to plow through all of it looking for several examples. In this context, the discussion of mesh generation software in Chapter 14 is much too limited. It has the appearance of a haphazard collection of material that has crossed the author's desk. A comprehensive listing and review of the capabilities and limitations of mesh generation packages available worldwide would enhance the utility of the book immensely. Indeed, such a chapter might be worth the price of the book!

In summary, the book is an excellent introduction to finite element mesh generation technology. It is valuable for newcomers to the subject or for scientists and engineers who require a basic understanding of the workings of mesh generation schemes in current finite element production software. The coverage is sufficient to allow conceptual understanding but lacks the detail necessary to allow for immediate application of the methods covered. For that, other texts or the literature will need to be consulted.

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