Book review

Finite Element Mesh Generation

Daniel S. H. Lo. CRC Press, Boca Raton, FL, USA, 2015,
ISBN 9780415690485, £103.99, 672 pp.

The finite-element method has become a standard tool for engineers in many disciplines. However, the quality of the results depends critically on the quality of the finite-element mesh used to discretise the domain. In most cases, meshes will be generated using a mesh generation tool. The engineer will most likely have an intuitive feel of whether a mesh is good or bad, but will often have little understanding of the techniques that are used to produce this mesh. While it is perfectly possible to be a good engineering analyst without understanding the processes, a better understanding of the tools used can help avoid problems or provide a way forward should a problem arise.

Professor Lo's book has something for both those who want to get a background understanding of how their finite-element meshes are produced, and also for those who want to understand the details of the algorithms. Each chapter and section has a good introduction outlining the ideas to be covered. For those who just want an introduction to meshing, this book gives the key concepts. Those after more detail will find the ideas expanded and described in more detail in the remainder of the chapter.

One thing that is clear from this book is that producing a good finite-element mesh is complex, so there is no single approach to produce a good mesh. The book compares different approaches while focusing on the most commonly used techniques.

After an introduction to the finite-element method, the terminology used in mesh generation is defined and the basic geometrical ideas reviewed. With the basics established, the book then looks at mesh generation, starting with two-dimensional (2D) planar surfaces. The key techniques of Delaunay triangulation and advancing front are introduced and the application in the generation of triangular meshes is described. The techniques used for 2D planar surfaces are then extended to include 2D curved surfaces. Having covered the basics for 2D surfaces, the book then goes on to cover the meshing of three-dimensional solids.

The techniques described in these chapters will result in a mesh, but this may not be the best or most appropriate mesh; so a chapter on mesh optimisation looks at how as a post-generation step this mesh can be improved, before it is used for analysis. For many this is likely to be the most useful chapter of the whole book, as the methods for improving the mesh are closely related to the methods for quantifying the quality of the mesh.

As the finite-element method has developed and the computer hardware to run finite-element models has become more powerful, model sizes have increased considerably. As we get to the position where finite-element models are measured in millions of elements rather than thousands there is a need to spread the work over several cores or processors to ensure efficiency. A chapter in this book is devoted to mesh generation using parallel processing, describing how the meshing techniques described earlier can be adapted for problems where the domain has to be split.

A final chapter looks at various auxiliary meshing techniques. Probably the most useful section in this chapter considers adaptive meshing, a technique that is becoming relevant as more use is made of finite-element analysis for non-linear problems where, as the analysis proceeds, the deformation can lead to severe degradation of the mesh, requiring remeshing during analysis to maintain accuracy.

Finally, the author provides the Fortran code that uses the techniques described in the book to create a 2D planar mesh generation using the advancing front method. This useful appendix gives an opportunity for those wanting to see in more detail how these techniques work in real code.

This book is aimed at those who want a comprehensive overview of the techniques of finite-element mesh generation. The techniques and algorithms are clearly explained and there are good references to follow up where greater detail is required. However, there is probably a broader readership among practising engineers, who use the finite-element method on a daily basis, and who want a better understanding of the tools they rely on as a basis for their calculations.

Stephen Hendry