mesh refinement are covered; mesh coarsening and mesh smoothing are not.

One of the main strengths of the book is the coverage of bivariate functions over triangulations. These functions are piecewise linear over the triangulation and are used to approximate bivariate functions as well as discrete data. This problem gives rise to a kind of triangulation which is not considered in CG: the data dependent triangulation. For this, triangles are not optimal with respect to a Delaunay criterion but rather they are constructed such that they "line up" optimally with a given function.

The chapter on least squares approximations is excellent. It shows how to realistically approximate huge data sets by a manageable piecewise linear surface. A mix of interpolation and approximation is also covered which is important in several applications.

The book is meant as a text for a graduate class on triangulations. Such a class would fit into the area of scientific computing or numerical analysis. A course text should have problems and exercises, and indeed there are about eight problems at the end of each chapter, with a good mix of theoretical problems and programming exercises.

For the programming part, students (as well as other readers) do not have to start from scratch: a complete software package is available from a companion web site. There one can find descriptions of the basic data structures as well as algorithms for constrained and unconstrained Delaunay triangulations, a triangulation editor, and various query tools. This reviewer did not try it out, but knowing that it is based on highly successful work by the Norwegian SINTEF organization, there is little doubt that it is a good product.

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Gerald Farin
Arizona State University

Large-Eddy Simulations of Turbulence. *By Marcel Lesieur, Olivier Metaís, and Pierre Comte.* Cambridge University Press, Cambridge, UK, 2005. $65.00. xii+219 pp., hardcover. ISBN 0-521-78124-8.

Hydrodynamic turbulence is often referred to as the last open problem of classical mechanics. Despite nearly a century of efforts by the best minds, many questions remain open, and considerable progress has only been achieved for the special case of homogeneous and isotropic turbulence in three dimensions [15, 16, 4]. To a lesser extent, there has also been some progress toward understanding homogeneous and isotropic turbulence in two dimensions [11, 20, 5]. On the theoretical front there has been very limited success in understanding inhomogeneous turbulence, compressible turbulence, and geophysical turbulence.

Our intuitive understanding of turbulence goes back to Richardson [18], Kolmogorov [9, 8], and Batchelor [1], who conjectured that if energy is injected into the system by forcing at large scales, then for sufficiently large Reynolds number, hydrodynamic instability results in the transfer of energy to smaller scales, and for sufficiently small scales this energy is dissipated by viscosity. In between the forcing length scale ℓ_0, where the energy comes in, and the dissipation length scale η, where the energy comes out, there is a range of scales, where the energy is cascaded by local nonlinear interactions from wavenumber to wavenumber down the range. This region is called the *inertial range*, and it was conjectured by Kolmogorov that it is governed by universal statistical principles. The conjecture was motivated by the notion that at length scales in the inertial range, the system forgets how the energy gets there, and the only dynamics in the inertial range is the transfer of energy to smaller scales. This conjecture leads to predictions about the energy spectrum $E(k)$ of turbulence as well as the scaling properties of the statistical moments of velocity differences.

Kolmogorov's idea remained a conjecture until 1962, when it was confirmed experimentally by measurements of the velocity of deep oceanic currents [6]. It was in that same year that Kolmogorov [10] and

Oboukhov [17] suggested that there may be a small departure from his original predictions, and further work over the next decades showed that this was indeed true [19]. So, one of the open questions that has received a lot of theoretical attention is, Why is the energy spectrum $E(k)$ of turbulence in the inertial range in such significant agreement with the predictions of Kolmogorov's 1941 theory (K41), and what is the origin of the deviations from that theory?

Now, one can argue that we already have a pretty good theory of hydrodynamic turbulence: the Navier–Stokes equations! All the physics of the Kolmogorov energy cascade can come from the numerical solution of the Navier–Stokes equations! The problem is that a numerical solution of the Navier–Stokes equations by direct numerical simulation is not possible for Reynolds numbers large enough to be of any practical interest. To the best of my knowledge, the state of the art in direct numerical simulations is 4096^3 resolution [7], performed by one of the largest supercomputers in the world, the Earth Simulator in Japan. Furthermore, for geophysical fluid dynamics and engineering applications one has to go beyond the Navier–Stokes equations and consider more accurate models that include temperature and density. A practical alternative to direct numerical simulation is large eddy simulation (LES), the topic of the book under review. The essential idea is that in practical situations we are interested in the effect of turbulence on fluid motions at large scales, so we go ahead and model the nonlinear dynamics at smaller scales so that it is not necessary to resolve them numerically.

The book begins in the preface with a delightful historical introduction by Jim Riley. The first chapter gives a very concise overview of the Kolmogorov theory as well as a conceptual introduction to LES in general. The second chapter gives a very interesting discussion of vortex dynamics which will be of interest to a wider audience of turbulence researchers. Emphasis is given to criteria that can be used to characterize coherent structures in turbulence. In addition to researchers of three-dimensional turbulence, this topic is also relevant to the investigation of two-dimensional turbulence as well as geophysical turbulence. Chapter 3 discusses the traditional LES models. Another chapter of general interest is Chapter 4, which discusses spectral LES models such as EDQNM and RNG. These models are often used, not only for numerical simulations, but also for theoretical arguments, as in, for example, [14]. There's also an interesting discussion of the famous "bump" in the inertial range energy spectrum, for which a variety of explanations have been suggested [2, 12]. The remaining chapters discuss various more modern LES models and a wide range of engineering and industrial applications of these models. Chapter 5 discusses models for inhomogeneous turbulence, Chapter 6 discusses structure function models, and Chapter 7 discusses models for compressible turbulence. Compressible turbulence is of unique interest due to its applications in aerodynamics and aerospace engineering. Finally, Chapter 8 discusses geophysical fluid dynamics, beginning with a very nice conceptual introduction, and emphasizes the modeling of storm formation.

For graduate students, I should note that the book does not give a comprehensive introduction to the *theory* of turbulence, Chapter 1 notwithstanding. One should also study other textbooks, starting from Frisch [3] and Lesieur [13], to gain a deeper appreciation of what is understood and what is not understood in this very exciting research area, before specializing into numerics. The book also doesn't discuss the numerical implementation of the corresponding simulation codes. On the other hand, the objective of the book, as stated in the introduction, is to present in detail a variety of LES models, and to give the reader a thorough understanding of turbulence dynamics through numerical results obtained by these models. The authors have done an excellent job in achieving these objectives. Furthermore, they have included material, such as in Chapter 7, that hasn't been reviewed previously in the literature, as well as material of general interest to the community, such as in Chapters 2 and 4. With its impressive bibliography, it will be an invaluable resource for students who want to study the literature of this field, as well as researchers who are currently working in LES.

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Eleftherios Gkioulekas
University of Central Florida

A Guide to MATLAB for Beginners and Experienced Users. Second Edition. *By Brian R. Hunt, Ronald L. Lipsman, and Jonathan M. Rosenberg.* Cambridge University Press, New York, 2006. \$50.00. xv+309 pp., softcover. ISBN 0-521-61565-8.

This is a readable introduction to using MATLAB 7 (and the immediate predecessor versions of MATLAB). Much of the book is devoted to describing how to use the various computational facilities provided by MATLAB and only a small proportion to the language itself and to its mathematical software library. The authors assume from the start that the reader has access to MATLAB, Simulink, and the Symbolic Toolbox,