Eur. J. Mech. B - Fluids 19 (2000) 531–532

S0997-7546(00)01096-7/BRV

Book review

Level Set Methods and Fast Marching Methods – Evolving Interfaces in Computational Geometry, Fluid Mechanics, Computer Vision, and Materials Science by J.A. Sethian (Cambridge University Press, Cambridge, UK, 1999, 2nd edition, 378 pp.) £18.95 paperback ISBN 0 521 64557 3

The Level Set method is a numerical method intended to follow propagating interfaces and fronts. Compared to more traditional methods, it has the very attractive advantages of being completely Eulerian, handling topological changes automatically, and avoiding any front reconstruction. Schematically, the principle is to define the front to be followed as the zero level of a function $\phi(\mathbf{x}, t)$, solution in the weak sense of a differential equation which can be numerically solved using the shock capturing schemes developed for gas dynamics.

The book introduces the method and gives an outlook over the large number of areas where it can be useful. This is the second edition, which is enriched by recent work of the author to extend and improve the method, and enlarge the domains of applications. Almost half of the book is devoted to the derivation of the level set equation and the associated numerical methods. The notion of entropy solutions and other basic notions for hyperbolic equations are introduced and lead to the construction of appropriate numerical schemes for the discretization of the level set equation. Some specific implementations improving the efficiency of the method are described, such as the narrow band level set method, and fast marching methods in the special case of a stationary boundary value formulation of the front motion. The new chapters deal mainly with the extension to triangulated unstructured meshes, and the construction of extended velocity in order to maintain a 'nice' level set representation. The latter point is shown to greatly improve the method, as if ϕ is not smooth across the front, the shock capturing schemes will add a lot of numerical diffusion that smear the front, leading to inaccuracies. A few test examples show an impressive improvement of the quality of the results, at the expense of a notably increased computing cost. The second part of the book presents a collection of applications and specific developments of the method in various fields, among which figure computational geometry or etching and deposition in microchip fabrication. If this convinces the reader of the universality of the method, there is, however, a lack of elements of comparison with other methods in realistic applications, such as would give the reader tools to appreciate the power of the level set method, and allow him to decide whether it is the most appropriate tool for such or such an application. People working in fluid mechanics will be disappointed that their domain is treated so briefly. VOF or front tracking methods have notoriously better conservation properties than the level set method, although things have been improved, since the first applications of level set methods in fluid mechanics, by the use of sophisticated reinitializations processes. This reader feels somewhat frustrated on this subject.

Throughout the book, a deliberate choice is made to rely on illustrative examples, and to avoid any complex mathematical developments as much as possible. This restricts the scope of the book, but makes it easy and pleasant to read, and gives the reader a global view of the method. A very large bibliography completes the book. To sum up, the book provides an appealing presentation of this elegant and powerful method, and, as such, is useful for anyone having an interest in interface problems.

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