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Introduction to Derivative-Free Optimization. *By Andrew R. Conn, Katya Scheinberg, and Luis N. Vicente*. SIAM, Philadelphia, 2009. $73.00. xii+277 pp., softcover. MOS-SIAM Series on Optimization. Vol. 8. ISBN 978-0-898716-68-9.

Introduction to Derivative-Free Optimization is bound to become the *de facto* authoritative text on numerical methods and the principles on which they rely for the solution of optimization problems in which derivatives are not available—whether they are not known to exist or are assumed to exist but are unavailable for a variety of reasons.

The introduction of the book begins by covering a few examples of applications of derivative-free optimization, the first of which is a personal favorite: the tuning of algorithmic parameters—a nonsmooth noisy problem. By the end of the introduction, the reader has been given a taste of applications and important aspects of numerical methods for derivative-free problems and of how various flavors of methods may be expected to compare in practice. This is, however, the only comparison between methods to be found in the book. As the authors point out, comparing derivative-free methods is intricate and is not an objective of the book.

In about 250 pages, the authors accurately convey the message that derivative-free optimization is an exciting field that offers a framework for virtually limitless modeling possibilities in applications—from proving conjectures to optimizing computer programs—but also that algorithm design in this field presents many challenges.

In the course of the book, the reader learns about both direct-search methods and model-based methods, as well as about their limitations—an aspect I particularly appreciated. The technical background material and the algorithmic discussions are conveniently separated into Part I and Part II. This makes it perfectly feasible for the interested reader to start studying algorithm design after a cursory reading of Part I, needing only to refer back to Part I when a more in-depth understanding is required. It is easy to imagine a graduate introductory class on derivative-free optimization designed along such lines.

Part II gives a general account of the algorithmic state of the art. Essentially, two frameworks are presented—direct-search methods and model-based methods—and the background for each one appears in corresponding sections of Part I. The two chapters dedicated to the direct-search framework cover methods such as the generalized pattern search, the mesh-adaptive pattern search, and convergent variants of Nelder and Mead's simplex method. The clarity, consistency, and rigor with which the paradigms of positive spanning sets and of poisedness are described in Part I render the discussion of Nelder and Mead's method almost a simple and didactic illustration of the direct-search framework.

In the text, model-based methods come in two varieties: linesearch methods and trust-region methods. The type of linesearch method covered is essentially a linesearch variant of the trust-region methods using simplex gradients to identify search directions. In the trust-region model-based methods chapters, the reader acquainted with *Trust-Region Methods* by Conn, Gould, and Toint, also published in the MOS-SIAM Series on Optimization (formerly the MPS-SIAM Series on Optimization), will appreciate the clearly stated similarities and differences between trust-region methods for smooth problems and for derivative-free problems. Interestingly, in *Trust-Region Methods*, which has one author in common with *Introduction to Derivative-Free Optimization*, 30 pages are dedicated to the minimization of "nonsmooth" (meaning locally Lipschitz) functions using trust-region methods. The context there is different from the present book, where it is assumed that the objective has a Lipschitz-continuous *gradient* or *Hessian* and that an interpolatory or least-squares model is built based on a well-poised sample set.

Part III briefly summarizes insights into current research and extensions. It mostly concerns the case of constrained problems and surrogate management. In the derivative-free world, a surrogate plays the role of a fortune teller, indicating whether or not certain regions might be promising for further exploration. The name *surrogate* is often used in contrast to the term *model*, as the latter might imply a certain approximation of the actual objective function. To the practitioner, a good surrogate may turn out to be the most important ingredient in a numerical method and the authors give several ways of including surrogates in the methods of Part II so as to retain their convergence properties.

In my opinion, the book is appropriate for a graduate class in optimization. Its shortcomings in this regard are that the exercises at the end of each section are mostly extensions of the theory and that there are few examples. While that is, of course, a respectable choice, a personal wish is that the exercises of Part II had given the reader a hands-on opportunity to experience the behavior of a basic implementation of each method—such bare-bones implementations would be an invaluable addition to the book for the student and researcher. While a short section of the book points to existing software, most of this software is research grade and not necessarily accessible to the nonexpert. The researcher, however, will surely find it a useful resource, and will appreciate the final notes at the end of each chapter, historical and otherwise, as well the extensive bibliography. By the end of the book the reader is up and running on derivative-free optimization and well equipped to read about cutting-edge developments in both direct-search methods and model-based methods.

All three authors of this book have carried out research in derivative-free optimization for many years and are central players in the field. As one of the most recent additions to the MOS-SIAM Series on Optimization at the time of writing, and as one of the very few textbooks available on this topic, *Introduction to Derivative-Free Optimization* is essential both as an introductory text and as a reference volume.

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