overhead in cases where this facility is not required. The experience gained in use of the conditional halt facility is currently being evaluated with a view to providing similar facilities implemented in hardware for a particular class of machine.

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References

ABRAMS, M. E., BOWDEN, K. F., CHAMBERLAIN, J. O. P., and MACCALLUM, I. R. (1968). *A Computer-Based General Practice and Health Centre Information System*, Journal of the Royal College of General Practitioners, Vol. 16, p. 515.

BOWDEN, K. F., MACCALLUM, I. R., and PATIENCE, S. P. (1971). *Data Structures for General Practice Records*. IFIP Congress Proceedings.

BURNETT, P. (1972). *An Interactive System to Simulate a Small Computer*. M.Sc. Dissertation, Computing Centre, Essex University.

Book reviews

Numerical Methods for Unconstrained Optimimization, edited by W. Murray, 1972; 144 pages. (*Academic Press Inc. (London)*, £3·00)

The main criticism I have to make about this book concerns the rather excessive delay in publication of the work. Dr. Murray explains in the preface that this was partly due to the delay in the decision to publish the proceedings of the IMA/NPL conference, held in January 1971. However, it is commendable that most of the contributors took advantage of the delay to revise their original papers to include material which has appeared since the conference.

The book provides an excellent introduction to the subject of unconstrained optimisation which is suitable not only for the non-specialist but also as an undergraduate course text. There are one or two printing errors, and, personally, I prefer the use of a heavy type x for the position vector of the variables, but the notation used is clearly explained in the Glossary of Symbols—an example other authors would do well to follow!

The chapters, or sections, of the book correspond to the papers given at the conference; after a brief introduction to 'Fundamentals' given by the editor, W. H. Swann gives a good practical survey of Direct Search methods, which could have included with advantage a numerical comparison of the methods described. This is followed by a chapter on 'Problems related to unconstrained optimization' by M. J. D. Powell, dealing with methods for functions which are sums of squared terms, and with the use of unconstrained techniques in constrained optimisation problems. The latter topic includes both the penalty and barrier function methods and the use of Lagrange parameter methods for problems with equality constraints.

Murray's description of 'Second derivative methods' commences with a summary of the advantages and disadvantages of the 'classical' steepest descent and Newton methods (the former is not a second derivative method, of course) and includes a discussion of the problems which arise if the Hessian matrix is not positive definite. If this is not the case the importance of the use of Choleski's method is stressed and a numerically stable modified Newton algorithm using this factorisation is described. A useful inclusion in the chapter is a description of the application of the Marquardt-Levenberg method when second derivatives are available. Fletcher's survey of 'Conjugate direction methods' starts with a review of the objectives of optimisation and conditions required for efficiency of any method; he shows that the conjugate direction methods meet these criteria and considers in turn methods which do and do not require calculation of the derivatives of the objective function. The chapter is concluded by relating these methods to the general class of Quasi-Newton methods which are described in detail by Broyden in the following chapter. The underlying principles of this class of method form the basis of Broyden's survey, and the paper includes a comparison of the use of various forms of update formulae for the approximation to the Hessian and its inverse.

The final two chapters are essentially practical in nature. In 'Failure, the causes and cures', Murray gives useful hints for dealing with programming errors, rounding errors and problems arising in transformation of variables; he also compares the numerical stability of the various classes of method, and finally discusses the use of algorithms with regard to choice of input parameters and interpretation of computer results. Fletcher's 'Survey of Algorithms for unconstrained optimisation' is also extremely useful from the practical point of view, but is, unfortunately, a subject which 'dates' very quickly and has therefore suffered most from the delay in publication. No reference is made to the NAG library the aim of which is to include the best available routines, written in both ALGOL 60 and FORTRAN, for most of the important topics in numerical analysis, including optimisation. One of the most useful features in the original paper was the flow chart for choice of algorithm for any practical problem—this has been omitted from the book, although it was included in the Harwell report of the paper (TP456).

To summarise, the book is well written and a very worthwhile purchase for both the specialist and non-specialist. One hopes that the IMA/NPL conference on *Constrained Optimization*, to be held early in 1974 will live up to the high standard set by its predecessor.

HEATHER M. LIDDELL (London)

Numerical Methods for Nonlinear Optimization, edited by F. A. Lootsma, 1972; 439 pages. (*Academic Press Inc., London*, £9·00)

The problem of finding the maximum or minimum value of a function of several variables is one which appears trivial until one actually has to solve it. For some considerable time now the main strategies have been well known. These include variable-metric, conjugate-gradient and non-gradient methods. However as the number of variables increases the tactical problems multiply and the economics of obtaining solutions begin to obtrude. Fairly trivial changes in the tactics employed in developing algorithms for solving these problems can make quite radical changes in the economics of the methods. Thus the importance of efficient algorithms has emerged.

This book is the report of a conference held at Dundee University in June-July 1971. It includes papers on the theoretical aspects of methods for unconstrained optimisation using variable-metric and conjugate-gradient methods. Particular methods for non-linear least squares and curve-fittings—in which some defined distance-function has to be minimised—are studied. Some attention is paid to the design of methods for finding global optima of problems that may have local non-global optima. There are also papers discussing problems of constrained optimisation.

Of recent years non-gradient methods have been somewhat neglected, but since these promise to be more sparing of computer storage space they have a particular potential when the number of variables is very large. There is some discussion of simplex type algorithms demonstrating this.

It would be invidious to choose any paper from this collection for special mention—the general standard is so high. A wealth of computational evidence is given about the performance of the algorithms discussed, and the tests used appear convincingly realistic. All in all this book is a valuable 'tool-box' for anyone faced with a non-linear optimisation problem.

As a footnote to an entertaining query raised by F. H. Branin about who was Raphson, D. J. Wilde's off-the-cuff reply that he was Newton's programmer is wide of the mark. Raphson appears to be the true author of the so called Newton-Raphson method. He gave it in his book Analysis Aequationum Universalis published in London in 1690.

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