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Book Reviews

editor, David W. Miller

Book Reviews Section, Graduate School of Business, 514 Uris Hall, Columbia University, New York, New York 10027

In response to the interest expressed by many members of TIMS, we shall list working papers by title and author at the end of the Book Reviews Section. Any interested author of a working paper should send a copy of it to the Book Reviews editor. Any working paper which is received by the editor will be listed without comment. It is hoped that this will provide better communication of the kind of work which is in progress and will permit direct contact among various persons who may be pursuing similar directions in their research.

PUN, LUCAS, *Introduction to Optimization Practice.* New York: John Wiley & Sons, Inc., 1969, 309 pp., $14.95.

This is a very useful book on optimization techniques. It has been written primarily for graduate students and practicing engineers but management scientists will also profit from it. The book is a model of careful organization. This is due to the attention which Professor Pun gave to the problem of "matching optimally the author and the reader." In his preface the author tells us that he ascribed primary importance to the decision as to how long his book should be. He also states that "a reasonable amount of difficulty is acceptable if the book is self-contained." In considering how his book could be useful to the reader Professor Pun decided: "They need exploitable information for dealing with the problems at hand. Also they need references to the more advanced literature." From his conclusions he deduced the outline of this admirably structured book.

In a very fine chapter, "Implications of Optimization Problems," the author gives an overview of the kinds of optimization problems, the ways of formulating them, the problem of a suitable performance index, the kinds of mathematical models, and the choice of an optimizing method. Chapter 2 is on "Static Optimization Techniques." Included are ordinary local maxima and minima, Lagrange multipliers, linear programming, and nonlinear programming, the latter including piecewise linearization, parametric linear programming, and Kuhn-Tucker convex programming.

Chapter 3 is on "Extremum Seeking Methods" and deals with Fibonacci search, steepest ascent search for multidimensional static problems, and extremum forcing search in dynamic problems. Chapter 4 is on "Dynamical Optimization Techniques" and covers variational methods, dynamic programming, and the method of gradients.

Chapter 5 discusses "Dynamical Suboptimization Techniques." Various sub-

optimization techniques are presented for dealing with the two-point-boundary-value problem, the dimensionality problem, and for improving the gradient method. For example, methods which are discussed for overcoming the 2PBVP are approximation of the unknown control function, invariant imbedding, Greenspan's method of discretizing the control function, and a generalized Newton-Raphson procedure.

As a result of the author's intention to make his book self-contained, there are appendices on matrices and vectors, simultaneous equations and quadratic forms, definitions relative to maxima and minima, convex sets and functions, the theory of general programming, duality, classical variational methods, the theory of the maximum principle, the relation between variational methods and continuous dynamic programming, and continuous dynamic programming and feedback control.

The exposition is remarkably clear throughout. There are numerous good examples and Professor Kun has the habit of carefully classifying anything which needs classification. The resulting little tables are extremely helpful. The bibliographies are excellent. In addition to the bibliographies given at the end of each chapter, there is a listing of 78 generally relevant books. Since this book was not intended as a text there are no problems. This fine book is strongly recommended to anyone who wants a clear overview of optimization problems and methods. Persons who have to deal with such problems would almost certainly benefit from reading it.

ZANGWILL, WILLARD I., *Nonlinear Programming: A Unified Approach.* Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1969, 356 pp., $12.50.

In this interesting book Professor Zangwill presents "a new and unified approach" to nonlinear programming. The newness stems mainly from the emphasis on the theory of the convergence of algorithms, to which the majority of the book is devoted. However, a variety of other topics are included which are not usually treated in books on this subject.

Chapter 1 discusses how nonlinear programming problems are formulated. Examples include consumer choice, control, geometric programming, and investment. Chapters 2 and 3 are devoted to methods for identifying an optimal solution. Chapter 2 covers the gradient vector, concavity and convexity, the Kuhn-Tucker necessary conditions, duality, and the question of sufficient conditions. It is shown that the Kuhn-Tucker conditions plus either suitable assumptions about the form of the functions or a stated Lagrangian condition give sufficiency. Chapter 3 is on "The Applications of the Kuhn-Tucker Conditions and Duality Theory". An interesting example of the economic interpretation of the Lagrangian and duality theory is obtained from "the competitive interaction between an industry and the market place". There are sections on the interpretation of the multipliers in the Kuhn-Tucker conditions, the dual of the geometric programming problem, and on optimal control and the maximum principle. Necessary conditions are developed for the optimal control problem which are not as general as Pontryagin's but which are obtained in a straightforward way from the Kuhn-Tucker conditions.

The remainder of the book is devoted to the problem of "moving from a point that is not a solution to one that is." This leads to the study of algorithms and the convergence theory mentioned above. In Chapter 4 Professor Zangwill proves his first convergence theorem. Since the theorem involves such notions as point-to-set maps it cannot be stated here. However, essentially it says that if an algorithm is sufficiently well-behaved then either the algorithm stops at a solution or else the limit of any convergent

subsequence is a solution. It should be noted that the theorem is more general than is implied by the previous statement because "solution" is more general than simply an optimal point. For example, a satisficing algorithm would fall within the compass of the theorem.

Chapter 5 applies the first convergence theorem to some algorithms for unconstrained problems. Specifically, the algorithms discusses are all feasible direction methods: the Cauchy steepest-ascent method, a modified Newton method, a cyclic-coordinate-ascent method, and a second-order method. Chapter 6 discusses mixed altorithms: one algorithm is used during that part of the optimization process for which it is most efficient and another is employed during another part of the process. The author proves a convergence theorem for well-behaved mixed algorithms and illustrates the use of conjugate-gradient methods in this context. Chapter 7 is very brief and simply gives some mathematical results concerning compactness and closedness.

Chapter 8 discusses NLP problems with linear constraints. Several methods for solving such problems are considered: linear approximations, the convex-simplex method, and the manifold-suboptimization method which considers only part of the constraints at each step. Chapter 9 specializes the methods of Chapter 8 in order to deal with the quadratic programming problem.

Chapter 10 develops two algorithms for the general NLP problem. The first is called the method of centers and was developed by Huard. The second is a Lagrangian algorithm which Professor Zangwill shows can be considered, in economic terms, as a kind of dynamic bargaining process between an industry and the market. He also shows that the theory of algorithmic convergence is connected with the Liapunov stability theory of difference or differential equations.

Some algorithms converge but do not satisfy the hypotheses of the two theorems mentioned above. Therefore, in Chapter 11 the author develops more general convergence theorems which are both necessary and sufficient for convergence. These methods proceed by solving a sequence of unconstrained problems which are approximations to a certain unsolvable unconstrained problem which is equivalent to the original NLP problem. Chapter 13 is devoted to feasible-direction methods and discusses the jamming problem. This can occur when the algorithmic map is not closed so the algorithm can generate a sequence of points which converges to a point which is not a solution. A feasible-direction method—called ϵ-perturbation—is presented which avoids jamming and, hence, converges. The final Chapter 14 presents three cutting-plane algorithms: the concave-cutting-plane method, the supporting-hyperplane method, and the dual-cutting-plane method.

The exposition is clear. There are a considerable number of exercises. Many of them add significantly to the text material. The mathematics needed is not excessive. The author suggests that some knowledge of linear programming, advanced calculus, and linear algebra is presupposed. Most management scientists become involved at one time or another with NLP problems and this book can be recommended as a useful integration of a sizable number of approaches to such problems.

SMITH, J. MAYNARD, *Mathematical Ideas In Biology*. Cambridge University Press, 1968, 152 pp., paperbound $1.95.

This is a very fine introduction to the use of mathematics in biology. The author's statement of what he wants to do in this book ought to be more widely imitated since many other fields could profit from it. He says: "Consequently, I have approached

mathematics in the spirit of one trying to teach French to a prospective visitor to Paris, and not to one about to sit an examination in French grammar." Professor Smith reminds us that there are three stages in applying mathematics to the real world. First we use our knowledge of the laws governing the system to write down an appropriate equation. Second, we solve the equation. And third, we interpret the result. He emphasizes: "In biology the difficult stage is the first one. We rarely know enough about the laws governing the components of biological systems to be able to write down the appropriate equation with any confidence in the first place. If an equation can be written down, it is usually possible to find a mathematician who will solve it, and if this is impossible, solutions can be found by a computer." And he adds: "Consequently, I have been more concerned in these pages to explain how equations can be written down than to describe how they can be solved."

The first chapter, "Some Consequences of Scale", has some interesting applications of the idea of similitude. Along with some fairly well-known examples of this kind of argument there are discussions of power output, running uphill, diving, and determination of an animal's optimal gait. Chapter 2 discusses population regulation with separate generations: there is an annual breeding season and there is no breeding between generations. This leads to difference-equation models. The author discusses density-dependent reproduction, delayed regulation, the predator-prey model, and an interesting model of the interaction between host and parasitoid. Chapter 3 deals with population regulation with mixing of generations. This leads to differential-equation models. The logistic equation is developed, the predator-prey model is considered again, a model of competing species is presented, and the effect of age structure is introduced.

Chapters 4 and 5 are devoted to the genetics of families and of populations, respectively. Chapter 6 is on "Target Theory", the analysis of the effects of random hits by ionising radiations, for example, on cells or organisms. Single-hit theories are considered—in these it is assumed that a single hit on any target within a cell will produce some measurable effect—and multi-hit theories—which require that all targets must be hit before the effect occurs.

Chapter 7 deals with "Regulation and Control" and discusses the control of muscular movements, the kinetics of chemical reactions, and the control of protein synthesis. Chapter 8 is on "Diffusion and Similar Processes" and includes a particularly interesting section on morphogenesis and the development of patterns.

The exposition is remarkably clear and cogent. Both mathematics and biology are relatively self-contained in the sense that the book can be read profitably by persons with either one of the two subjects. There are some interesting problems for the reader. This book can be strongly recommended as an introduction to the use of mathematics in biology. But it is also a good source for some interesting models and arguments which are excellent background material for any quantitative analyst.

SEILER, KARL, *Introduction to Systems Cost-Effectiveness*. New York: John Wiley & Sons, Inc., 1969, 108 pp., $9.95.

This is a very useful book but the difficulty is to define the audience which will find it so. In his preface, Mr. Seiler notes that "Until now it has not been possible to obtain a concise yet comprehensive textbook on cost-effectiveness theory and applications." Since he has given various courses on the subject and had available his notes he undertook to remedy this deficiency. In accomplishing his purpose I think Mr. Seiler has un-

duly emphasized the "concise" in the quotation above. In short, the bare bones of his noted have received little padding in the transition to a book. The result is more like an annotated outline than an exposition of the subject.

This granted, the book is "comprehensive." There are four chapters. Chapter 1, "Cost Factors", is a good summary of the problems of identifying and measuring costs. Chapter 2, "System Cost Models," covers such topics as period costing, time phasing, prorating fixed costs, nonlinearity of variable costs, differential cost models, and so forth. Chapter 3, "System Effectiveness Models," treats availability, reliability, survivability, model expansion, maximizing total system effectiveness, time phasing, and so forth. Chapter 4, "System Cost-Effectiveness Models," deals with domain of feasibility, homogeneity, ratio models, indifference curve models, a very interesting section on probabilistic cost-effectiveness, and other topics.

There are lots of very interesting approaches discussed in this book but, as noted, the presentation is extremely terse. Calculus and probability theory are assumed. I am convinced that I would like to hear Mr. Seiler's lectures on this subject but I wish he had added some of his examples and discussion to this book. As it is, the reader must be able to add a good deal from his own experience in order to appreciate Mr. Seiler's presentation. I conclude that it is an excellent book for anyone who can read it.

KING, LESLIE J., *Statistical Analysis in Geography*. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1969, 288 pp., $6.95.

This is a good introduction to statistical analysis in geography. It may be of interest to readers of this journal because similar problems arise in management science and methods for coping with them are not usually discussed in ordinary textbooks on statistics. Thus, there are discussions of the use of modified and compound Poisson laws for describing spatial point processes; sampling designs for spatial patterns; distance measures for the description of observed point patterns, including nearest-neighbor measures; randomness of points in two-dimensional patterns; an interesting analysis of the effect of a random disturbance on a uniform pattern; randomness of the distribution of points by quadrat; the problem of the correspondence of point patterns; trend surface analysis, which involves the regression of some mapped dependent variable against the orthogonal coordinates for the map area; the problem of modifiable units—in correlation analysis based on areal units the correlations obtained vary when the sizes of the areal units changes; spatial autocorrelation; the use of principal components and factor analysis; the use of distance statistics as measures of similarity and classification based on distance statistics; classification based on linear discriminant functions; the use of canonical correlation analysis; and much else besides. The presentation is at an elementary level but there are good bibliographical references to the original literature. Since so many of the mentioned topics are not part of the usual tools of the statistician, many management scientists ought to find this an interesting and useful book.

HOLLAND, JANET AND M. D. STEUER, *Mathematical Sociology: A Selective Annotated Bibliography*. The London School of Economics and Political Science, 1969, 109 pp., 40 shillings.

This is an extremely useful addition to the literature dealing with applications of mathematics to the social sciences. Contributions in the area of mathematical sociology are quite widely scattered. As a result, many models which might be of considerable

interest in several subject areas are known only to specialists. This book will surely help to remedy this situation. The bibliography includes 340 articles and 111 books. The annotations are short but they do provide a good deal of the information needed in order to decide whether the given reference is relevant to a particular interest. This book can be recommended as a valuable guide to the literature on mathematical sociology.

All unsigned reviews are written by the Book Reviews editor.