RALPH DEUTSCH, *Estimation Theory*. Prentice-Hall, Englewood Cliffs, 1965. xiv + 269 pp. $9.75.

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Estimation theory is an important discipline of great practical importance in many areas, as is well known. Recent developments in the information sciences—for example, statistical communication theory and control theory—along with the availability of large-scale computing facilities, have provided added stimulus to the development of estimation methods and techniques and have naturally given the theory a status well beyond that of a mere topic in statistics. The present book is a timely reminder of this fact, as a perusal of the table of contents (covering thirteen chapters) indicates:

Chapter 1 provides a concise historical account of the growth of the theory; Chapters 2 and 3 introduce the notions of estimates, estimators, and optimality, while Chapters 4 and 5 are devoted to Gauss' method of least squares and associated linear estimates and estimators. Chapter 6 approaches the problem of nonlinear estimates (which in statistical communication theory are the rule rather than the exception); Chapters 7 and 8 provide additional mathematical techniques (matrix inverses, pseudo inverses, iterative solutions, sequential and recursive estimation). In Chapter 9 the concepts of moment and maximum likelihood estimators are introduced, along with more of their associated (asymptotic) properties, and in Chapter 10 the important practical topic of estimation errors is treated, their sources, confidence regions, numerical errors and error sensitivities. Chapter 11 is a sizable one, devoted to a careful, quasi-introductory exposition of the central topic of linear least-mean-square (LLMS) smoothing and prediction, with emphasis on the Wiener-Kolmogoroff theory. Chapter 12 is complementary to Chapter 11, and considers various methods of obtaining the explicit optimum processing (filters) for (LLMS) prediction and smoothing, e.g. the Kalman-Bucy method, discrete time difference equations, and Bayes estimation (briefly). Chapter 13 completes the book, and is devoted to an introductory exposé of decision theory as it is specifically applied to the central problems of signal detection and extraction in statistical communication theory. Here, of course, the emphasis is on the Bayes theory [1].

The book is clearly written, at a deliberately heuristic though not always elementary level. It is well-organized, and as far as this reviewer was able to observe, very free of misprints. However, the reviewer feels that certain topics are handled in an unnecessarily restricted way: the treatment of maximum likelihood (Chapter 9) is confined to situations where the *a priori* distributions of the parameters under estimation are (tacitly) taken to be uniform (formally equivalent to the so-called conditional ML estimates of the earlier, classical theories). Pugachev's alternative formulation of signal detection and extraction under the Bayes

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framework (Section 13–16) is unnecessarily involved for the apparent simplification of handling detection and extraction with a single general class of cost functions—this is more obviously and naturally handled in the original formulation, [1] which is also not restricted to solely normal noise (and/or signal) processes. The rôle of *a priori* information and what to do when it is only partially or even totally unavailable is not in many cases adequately considered. Although exercises are provided at the end of each chapter, their number, at least, appears to be somewhat meager for pedagogical purposes.

These criticisms, however, are relatively minor. The book brings together in a single, convenient form a very considerable body of useful material (including an extensive list of references), which is on the whole effectively and accurately presented, and which should be of real assistance and interest to the communication theorist, the control engineer, applied physicist, and by no means least, the statistician himself.

REFERENCE

[1] MIDDLETON, D. (1960). *Introduction to Statistical Communication Theory*. McGraw-Hill, New York. Part IV; also see *Topics in Communication Theory* (1965), McGraw-Hill.