Detection and Estimation for Communication and Radar Systems

Covering the fundamentals of detection and estimation theory, this systematic guide describes statistical tools that can be used to analyze, design, implement, and optimize real-world systems. Detailed derivations of the various statistical methods are provided, ensuring a deeper understanding of the basics. Packed with practical insights, it uses extensive examples from communication, telecommunication, and radar engineering to illustrate how theoretical results are derived and applied in practice. A unique blend of theory and applications, and more than 80 analytical and computational end-of-chapter problems, make this an ideal resource for both graduate students and professional engineers.

Kung Yao is a Distinguished Professor in the Electrical Engineering Department at the University of California, Los Angeles. He received his BS (Highest Honors) and Ph.D. from Princeton University. A Life Fellow of the IEEE, he has worked for or consulted for several leading companies, including AT&T Bell Laboratories, TRW, Hughes Aircraft Company, and Raytheon.

Flavio Lorenzelli received his Ph.D. from the University of California, Los Angeles, and for several years was with ST Microelectronics. The recipient of a Fulbright fellowship in 1989, he has been an engineer at the Aerospace Corporation since 2007 and is a Lecturer in the Electrical Engineering Department at UCLA.

Chiao-En Chen is an Assistant Professor in both the Department of Electrical Engineering and the Department of Communications Engineering at National Chung Cheng University, Taiwan. He received his PhD from the University of California, Los Angeles, in 2008.

"This text is tailor-made for first year graduate students, with its easy-to-follow presentation style, self-contained background materials, and even simulation methods that are perfect for new learners and practitioners."

Zhi Ding, University of California, Davis

"Making things as simple as possible, but not simpler, is an art well mastered by the authors, whose teaching experience shines through the whole book and makes it an ideal text for electrical engineering students, especially those taking courses in wireless communications. The panoply of examples and homework problems included in the book makes it also an invaluable tool for self-study."

Ezio Biglieri, University of California, Los Angeles

"This book strikes a good balance between engineering insight and mathematical rigor. It will make an excellent textbook for either an advanced undergraduate class or a first-year graduate class on detection and estimation theory."

Laurence Milstein, University of California, San Diego

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KUNG YAO
University of California, Los Angeles

FLAVIO LORENZELLI
The Aerospace Corporation, Los Angeles

CHIAO-EN CHEN
National Chung Cheng University, Taiwan

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To my wife, Mary, and my children, David, Erica, and Roger

K.Y.

To my mom

F.L.

To my family

C.E.C.

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Preface

This publication was conceived as a textbook for a first-year graduate course in the Signals and Systems Area of the Electrical Engineering Department at UCLA to introduce basic statistical concepts of detection and estimation and their applications to engineering problems to students in communication, telecommunication, control, and signal processing. Students majoring in electromagnetics and antenna design often take this course as well. It is not the intention of this book to cover as many topics as possible, but to treat each topic with enough detail so a motivated student can duplicate independently some of the thinking processes of the originators of these concepts. Whenever possible, examples with some numerical values are provided to help the reader understand the theories and concepts. For most engineering students, overly formal and rigorous mathematical methods are probably neither appreciated nor desirable. However, in recent years, more advanced analytical tools have proved useful even in practical applications. For example, tools involving eigenvalue–eigenvector expansions for colored noise communication and radar detection; non-convex optimization methods for signal classification; non-quadratic estimation criteria for robust estimation; non-Gaussian statistics for fading channel modeling; and compressive sensing methodology for signal representation, are all introduced in the book.

Most of the material in the first seven chapters of this book can be covered in a course of 10 weeks of 40 lecture hours. A semester-long course can more thoroughly cover more material in these seven chapters and even some sections of Chapter 8. Homework problems are provided in each chapter. The solutions of odd-numbered problems are available from the Cambridge University Press website. The solutions of the even-numbered problems are available (also from Cambridge University Press) to instructors using this book as a textbook. The prerequisites of this book include having taken undergraduate courses on linear systems, basic probability, and some elementary random processes. We assume the students are familiar with using Matlab for computations and simulations. Indeed, some of the statements in the book and in the homework problems use standard Matlab notations.

Comments and references including bibliographic information are provided at the end of each chapter. The authors of this book certainly appreciate the extensive prior research in journal and book publications on all the topics covered in this book. Omissions of references on some technical topics/methodologies, and even some homework problems that may have appeared elsewhere, are not intentional. In such cases, we seek your understanding and indulgence.