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Bing Li · G. Jogesh Babu

A Graduate Course on Statistical Inference

Springer

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To our parents:
Jianmin Li and Liji Du
Nagarathnam and Mallayya

and to our families:
Yanling, Ann, and Terrence
Sudha, Vinay, and Vijay

Preface

It is our goal to write a compact, rigorous, self-contained, and accessible graduate textbook on statistical estimation and inference that reflects the current trends in statistical research.

The book contains three main themes: the finite-sample theory, the asymptotic theory, and Bayesian statistics. Chapters 2 through 4 are devoted to the finite-sample theory, which includes the classical theory of optimal estimation and hypothesis test, sufficiency, completeness, ancillarity, and exponential families. Chapters 5 to 6 are devoted to Bayesian statistics, covering prior and posterior distributions, Bayesian decision theory for estimation, hypothesis testing, and classification, empirical Bayes, shrinkage estimates. Chapters 8 through 11 are devoted to asymptotic theory, covering consistency and asymptotic normality of maximum likelihood estimation and estimating equations, the Le Cam-Hajek convolution theorem for regular estimates, and the asymptotic analysis of a wide variety of hypothesis testing procedures. Two chapters on preliminaries are included to make the book self-contained: Chapter 1 contains preliminaries for the finite-sample theory and Bayesian statistics; Chapter 7 for the asymptotic theory.

The topics and treatment of some material are different from a typical textbook on statistical inference, which we regard as a special feature of this book. For example, we devoted a chapter on estimating equations and used it as a unifying mechanism to cover some useful methodologies such as the generalized linear models, generalized estimation equations, quasi likelihood estimation, and conditional inference. We include a systematic exposition of the theory of regular estimates, from regularity, contiguity, the convolution theory, to asymptotic efficiency. This theory was then used in conjunction with the Local Asymptotic Normal (LAN) assumption to develop asymptotic local alternative distributions and the optimal properties for a wide variety of hypothesis testing procedures that can be written as quadratic forms in the limit.

One of the features of the book is the systematic use of a parsimonious set of assumptions and mathematical tools to streamline some recurring regularity conditions, and theoretical results that are fundamentally similar. This makes the development of the methodology more transparent and interconnected, and the book a coherent whole. For example, the conditions "differentiable under the integral sign (DUI)", and "stochastic equicontinuity" are repeatedly used throughout many chapters of the book; the geometric projection and the multivariate Cauchy-Schwarz inequality are used to unify different types of optimal theories; the structures of asymptotic estimation and hypothesis testing echo their counterparts in the finite-sample theory.

This book can be used either as a one-semester or a two-semester textbook on statistical inference. For the two-semester courses, the first six chapters can be used for the first semester to cover finite-sample estimation and Bayesian statistics, and the last five for the second semester to cover asymptotic statistics. For a one-semester course, there are several pathways depending on the instructor's emphasis. For example, one possibility is to use Chapters 1, 3, 4, 7, 10, 11 for an advanced course on hypothesis testing; another possibility is to use Chapters 1, 2, 5, part of 6, 7, 8, 9 as an advanced course on point estimation and Bayesian statistics.

The book grew out of the lecture notes for two graduate-level courses that we have taught for more than two decades at the Pennsylvania State University. Over this period we have revamped the courses several times to adapt to the evolving trends, emphases, and demands in theoretical and methodological research. The authors are grateful to the Department of Statistics of the Pennsylvania State University for its constant support and the stimulating research and education environment it provides. The authors also gratefully acknowledge the support from the National Science Foundation grants.

State College
April 2019

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