

MONTE CARLO STATISTICAL METHODS

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2nd ed. Springer: New York, 2004

ISBN 0-387-21239-6

pp. 645 + XXX, 132 illustrations, hardcover

price: 89.95 €

This is the revised second edition of a textbook on statistical methods based on simulation, particularly those based on Markov Chains. Being a textbook, the authors have made an effort to compile, summarize and organize the prolific literature on the field that now has reached a status mature enough to be used as standard techniques for statisticians. The text pays special attention to introduce solidly the main concepts and allows the reader to access easily the more recent developments in the subject. The intended reader should have previous knowledge of statistical inference, but no previous knowledge about Monte Carlo techniques nor Markov Chains theory are needed. Postgraduate students, researchers or practising statisticians aiming to use these techniques will greatly benefit from reading this text. The concepts are clearly explained, with detail when needed, and the theorems have proofs. Also many practical examples are used throughout the book to illustrate the methods. Great effort has been made to enumerate and detail the algorithms. These are printed inside grey-colour boxes for easy identification. Algorithms are explained with pseudo-code to make easy translation to any programming software. No real implementations of the code are done in the book, though the authors mention that the examples were actually implemented in C and references to the BUGS software are given. As a text book intended for classroom use, many problems are proposed at the end of each chapter, without solution. Also short notes covering complementary material are given after the problems section of each chapter. The book has a big deal of references and, though most are prior to the first edition of 1999, many new ones covering recent developments have been added in this second edition.

The book is organized in 14 chapters. The first is a short introduction on likelihood and Bayesian statistical methods, giving motivating examples of difficult problems of inference that can be solved easier by simulation methods. The second chapter introduces the reader into the field of simulation reviewing different methods of random variable generation. For each method, the theory is detailed and algorithms

to facilitate the implementation are presented. Two chapters covering the Monte Carlo integration follow this introductory part (introductory but long and rigorous, like the rest of the book). One presents the Monte Carlo methods to approximate univariate and multidimensional integrals. Next discusses methods to estimate and control the variance of the Monte Carlo estimator. The use of Monte Carlo techniques in order to solve optimization problems are presented in chapter 5. Here the authors contrast stochastic methods for exploration (simulation methods to find the maximum) and methods for approximation of the objective function. In this sense, several methods are reviewed like the *simulated annealing* or the *EM algorithm*. Chapter 6 covers the theory of Markov Chains. First we find an explanation of main the results that are needed to establish the convergence of the MCMC techniques. The goal of this initial section is to advise readers who are more interested in the implementations topics of MCMC than in theoretical details. This is followed by a more comprehensive exposition of the theory, including the proofs of the theorems of convergence. The book then progresses through 5 chapters detailing specific techniques of MCMC, with emphasis on algorithms for easy implementation: the general *Metropolis-Hastings algorithm*, the *slice sampler* and the *Gibbs sampler*. For models contemplating a variable number of dimensions, the *reversible jump* algorithms are explained in detail. Chapter 12 presents a selection of useful methods to assess convergence and the notes comment the software CODA for this purpose. Finally, the last two chapters are dedicated to new developments in the field of MCMC, methods that emerge strongly like the *perfect sampling* and the *iterated and sequential importance sampling*.

In summary, this book is attractive to read because it is full of motivating examples. It will be very useful to those interested in implementing the algorithms, because these are clearly explained. The theoretical bases for the methods are covered in detail and this introduces the student or researcher to the background needed to follow the specialized literature of the field, which is prolific.

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