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Monte Carlo Methods

Neal Madras
Editor

American Mathematical Society

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FIELDS INSTITUTE COMMUNICATIONS

THE FIELDS INSTITUTE FOR RESEARCH IN MATHEMATICAL SCIENCES

Monte Carlo Methods

Neal Madras
Editor

American Mathematical Society
Providence, Rhode Island

The Fields Institute for Research in Mathematical Sciences

The Fields Institute is named in honour of the Canadian mathematician John Charles Fields (1863–1932). Fields was a visionary who received many honours for his scientific work, including election to the Royal Society of Canada in 1909 and to the Royal Society of London in 1913. Among other accomplishments in the service of the international mathematics community, Fields was responsible for establishing the world's most prestigious prize for mathematics research—the Fields Medal.

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Contents

Preface vii

Invited Papers

Introduction to Multicanonical Monte Carlo Simulations 1
BERND A. BERG

MCMC in $I \times J \times K$ Contingency Tables 25
FLORENTINA BUNEA and JULIAN BESAG

Extension of Fill's Perfect Rejection Sampling Algorithm to General Chains 37
JAMES ALLEN FILL, MOTOYA MACHIDA, DUNCAN J. MURDOCH and JEFFREY S. ROSENTHAL

Taming Zero Modes in Lattice QCD with the Polynomial Hybrid Monte Carlo Algorithm 53
KARL JANSEN

Monte Carlo Algorithms and Non-Local Actions 65
A. D. KENNEDY

Towards a More General Propp-Wilson Algorithm: Multistage Backward Coupling 85
XIAO-LI MENG

On Non-Reversible Markov Chains 95
ANTONIETTA MIRA and CHARLES J. GEYER

Exact Sampling for Bayesian Inference: Unbounded State Spaces 111
D. J. MURDOCH

Recent Progress on Computable Bounds and the Simple Slice Sampler 123
GARETH O. ROBERTS and JEFFREY S. ROSENTHAL

MCMC Methods in Statistical Mechanics: Avoiding Quasi-Ergodic Problems 131
STUART G. WHITTINGTON

Layered Multishift Coupling for Use in Perfect Sampling Algorithms (with a primer on CFTP) 143
DAVID BRUCE WILSON

Poster Session

Introduction to Semi Markov Chain Monte Carlo 181
HÅKAN LJUNG

Accelerated Simulation of ATM Switching Fabrics 193
A. R. DABROWSKI, G. LAMOTHE and D. R. MCDONALD

Some Stratagems for the Estimation of Time Series Using the Metropolis Method 207
ANDREW R. RUNNALLS

Monte Carlo Study of Adsorption of Interacting Self-Avoiding Walks 221
TEREZA VRBOVÁ

Preface

This volume contains the proceedings of the Workshop on Monte Carlo Methods held at the Fields Institute for Research in Mathematical Sciences, October 25–29, 1998, in Toronto, Ontario, Canada. The co-organizers of the workshop were Neal Madras, Radford Neal, and Jeffrey Rosenthal. This event was part of a thematic program on Probability and Its Applications at the Fields Institute, from August 1998 through June 1999.

Monte Carlo methods have been used intensively in many branches of scientific inquiry over the past several decades. Markov chain methods have been at the forefront of much of this work. They have been the basis of much numerical work in statistical physics and related disciplines ever since the Metropolis algorithm was introduced in 1953. Statisticians were using such methods for some problems during the 1970's, but Markov chain Monte Carlo methods did not really enter the mainstream of statistical activity until about ten years ago. In addition, theoretical computer scientists began to get interested in these methods in the mid 1980's. With all of this activity, researchers in probability theory also turned their attention to this subject, reinvigorating the study of Markov chains with an entirely new outlook. However, as is often the case, there was a lack of communication between scientists of different backgrounds. They were working on different fundamental research questions, yet they were using similar Monte Carlo methodology. Often the same practical issues arose in different fields, and solutions would be developed in parallel by two communities of researchers with little overlap.

The purpose of this workshop was to bring together researchers in physics, statistics, and probability, and to promote discussion across these disciplines. The focus was on Monte Carlo methods that appear to have wide applicability, emphasizing new methods, practical applications, and theoretical analysis. The workshop drew over one hundred participants from a variety of disciplines, including several nonacademic registrants. To help acclimatize the different groups to one another's viewpoint, we scheduled four special overview talks: "Tutorial on Monte Carlo Applications in Statistics" (by Radford Neal), "Tutorial on Monte Carlo Applications in Statistical Physics" (by Stuart Whittington), "Review of Exact Sampling Methods" (by Radford Neal), and "Tutorial on Lattice Field Theory Monte Carlo" (by Anthony Kennedy). In this volume, Whittington's article includes an introduction to statistical mechanics applications, and Wilson's article contains an introduction to exact sampling by "coupling from the past".

This volume includes papers by most of the workshop's invited speakers, as well as some of the contributors to a successful poster session held on the fourth day of the workshop. In keeping with the interdisciplinary nature of the workshop, the speakers aimed their talks at a broader audience than would be normal at a more specialized conference. We have tried to maintain this approach in these proceedings.

I would like to record my thanks to Radford Neal and Jeffrey Rosenthal, the other two-thirds of the program committee for the workshop. On their behalf, I am happy to thank the staff at the Fields Institute for their assistance in the planning, organization, and administration of the workshop. Particular gratitude is due to Alesia Zuccala, who oversaw the nitty gritty details of the event as the Fields Workshop Coordinator, and then moved on to become the Fields Institute's Publication Manager, where she has provided further expertise in the compilation of these proceedings.

I would also like to thank those who served as referees or who otherwise provided valuable assistance in the preparation of this volume: John Baxter, David Ceperley, Mike Evans, Daan Frenkel, Peter Green, David Higdon, Mark Huber, Radford Neal, Mauro Piccioni, Buks van Rensburg, Jeffrey Rosenthal, Richard Silver, Peter Song, Christine Soteros, Raj Srinivasin, and Wai Kong (John) Yuen.

Neal Madras
Editor

January 2000

Monte Carlo Methods

Neal Madras, Editor

This volume contains the proceedings of the Workshop on Monte Carlo Methods held at The Fields Institute for Research in Mathematical Sciences (Toronto, 1998). The workshop brought together researchers in physics, statistics, and probability. The papers in this volume—of the invited speakers and contributors to the poster session—represent the interdisciplinary emphasis of the conference.

Monte Carlo methods have been used intensively in many branches of scientific inquiry. Markov chain methods have been at the forefront of much of this work, serving as the basis of many numerical studies in statistical physics and related areas since the Metropolis algorithm was introduced in 1953. Statisticians and theoretical computer scientists have used these methods in recent years, working on different fundamental research questions, yet using similar Monte Carlo methodology.

This volume focuses on Monte Carlo methods that appear to have wide applicability and emphasizes new methods, practical applications and theoretical analysis. It will be of interest to researchers and graduate students who study and/or use Monte Carlo methods in areas of probability, statistics, theoretical physics, or computer science.

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