MODELING UNCERTAINTY
An Examination of Stochastic Theory, Methods, and Applications

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MODELING UNCERTAINTY
An Examination of Stochastic Theory, Methods, and Applications

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Preface

This volume titled MODELING UNCERTAINTY: An Examination of Stochastic Theory, Methods, and Applications, has been compiled by the friends and colleagues of Sid Yakowitz in his honor as a token of love, appreciation, and sorrow for his untimely death. The first paper in the book is authored by Sid's wife – Diana Yakowitz – and in it Diana describes Sid the person, his drive for knowledge and his fascination with mathematics, particularly with respect to uncertainty modelling and applications. This book is a collection of papers with uncertainty as its central theme.

Fifty authors from all over the world collectively contributed 30 papers to this volume. Each of these papers was reviewed and in the majority of cases the original submission was revised before being accepted for publication in the book. The papers cover a great variety of topics in probability, statistics, economics, stochastic optimization, control theory, regression analysis, simulation, stochastic programming, Markov decision process, application in the HIV context, and others. Some of the papers have a theoretical emphasis and others focus on applications. A number of papers have the flavor of survey work in a particular area and in a few papers the authors present their personal view of a topic. This book has a considerable number of expository articles which should be accessible to a nonexpert, say a graduate student in mathematics, statistics, engineering, and economics departments, or just anyone with some mathematical background who is interested in a preliminary exposition of a particular topic. A number of papers present the state of the art of a specific area or represent original contributions which advance the present state of knowledge. Thus, the book has something for almost anybody with an interest in stochastic systems.

The editors have loosely grouped the chapters into 8 segments, according to some common mathematical thread. Since none of us (the co-editors) is an expert in all the topics covered in this book, it is quite conceivable that the papers could have been grouped differently. Part 1 starts with a paper on stability in queuing networks by H.J. Kushner. Part 1 also includes a queuing related

paper by T.L. Lai, and a paper by I. Pinelis on asymptotics for large deviation probabilities. Part 2 groups together 3 papers related to HIV modelling. The first paper in this group is by W.-Y. Tan and Z. Xiang about modelling early immune responses, followed by a paper of B. Barnes and J. Gani on the impact of re-using hypodermic needs, and closes with a paper by D.S. Stoffer. Part 3 groups together optimization and regression papers. It contains 4 papers starting with a paper by A. Nemirovski and R.Y. Rubinstein about classical stochastic approximation. The next paper is by B. Kedem and K. Fokianos on regression models for binary time series, followed with a paper by H. Walk on properties of Nadarya - Watson regression estimates, and closing with a paper on sequential predictions of stationary time series by L. Györfi and G. Lugosi. Part 4's 6 papers are in the area of economics analysis starting with a nonlinear oligopolies paper by C. Chiarella and F. Szidarovszky. The paper by A. Haurie and F. Moresino examines a differential game of debt contract valuation. Next comes a paper by D. Porter, followed by a paper about complex systems in relation to affordable upgrades by J.A. Reneke, M.J. Saltzman, and M.M. Wiecek. The 5th paper in this group, by F.-Y. Wang and G.N. Sardis, concerns optimal control in stochastic dynamic systems, and the last paper is by L. Gerencsér is about stability of random iterative mappings. Part 5 loosely groups 3 papers starting with a paper by V. Solo on Monte Carlo methods for adaptive algorithms, followed by a paper on random search with noise by L. Devroye and A. Krzyzak, and closes with a survey paper on randomized quasi-Monte Carlo methods by P. L'Ecuyer and C. Lemieux. Part 6 is a collection of 3 papers sharing a focus on Markov decision analysis. It starts with a paper by G. Yin, Q. Zhang, K. Yin, and H. Yang on singularly perturbed Markov chains. The second paper, on risk sensitivity in average Markov decision chains, is by R. Cavazos–Cadena and E. Fernández–Gaucherand. The 3rd paper, by G.G. Roussas, is on statistical inference in a Markovian framework. Part 7 includes a paper on order statistics by P.J. Boland, T. Hu, M. Shaked, and J.G. Shanthikumar, followed by a survey paper on routing with stochastic demands by M. Dror, a paper on fast Fourier and Walsh transforms by P.J. Sanchez, J.S. Ramberg, and L. Head, a paper by J.C. Spall on parameter estimation with limited data, and a tutorial paper on data compression by J.C. Kieffer. Part 8 contains 2 'reflections' papers. The first paper is by M. Sniedovich – an ex-student of Sid Yakowitz. It reexamines Bellman's principle of optimality. The last paper in this volume on statistical methods for complex stochastic systems is reserved to M.F. Neuts.

The efforts of many workers have gone into this volume, and would not have been possible without the collective work of all the authors and reviewers who read the papers and commented constructively. We would like to take this opportunity to thank the authors and the reviewers for their contributions. This book would have required a more difficult 'endgame' without Ray Brice's ded-

ication and painstaking attention for production details. We are very grateful for Ray's help in this project. Paul Jablonka is the artist who contributed the art work for the book's jacket. He was a good friend to Sid and we appreciate his contribution. We would also like to thank Gary Folven, the editor of Kluwer Academic Publishers, for his initial and never fading support throughout this project. Thank you Gary !

Moshe Dror Pierre L'Ecuyer Ferenc Szidarovszky

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This book is dedicated to the memory of Sid Yakowitz.

Chapter 1

PROFESSOR SIDNEY J. YAKOWITZ

D. S. Yakowitz
Tucson, Arizona

Sidney Jesse Yakowitz was born in San Francisco, California on March 8, 1937 and died in Eugene, Oregon on September 1, 1999. Sid's parents, Morris and MaryVee, were chemists with the Food and Drug Administration and encouraged Sid to be a life-long learner. He attended Stanford University and after briefly toying with the idea of medicine, settled into engineering ("I saved hundreds of lives with that decision!"). Sid graduated from Stanford with a B.S in Electrical Engineering in 1960.

His first job out of Stanford was as a design engineer with the University of California's Lawrence Radiation Laboratory (LRL) at Berkeley. Sid was unhappy after college but claimed that he learned the secret to happiness from his office mate at LRL, Jim Sherwood, who told him he was being paid to be creative. Sid decided that "Good engineering design is a synonym for 'inventing'."

For graduate school, Sid chose Arizona State University. By this time, his battle since childhood with acute asthma made a dry desert climate a mandatory consideration. In graduate school he flourished. He received his M.S. in Electrical Engineering in 1965, an M.A. in Mathematics in 1966, and Ph.D. in Electrical Engineering in 1967. His new formula for happiness in his work led him to consider each topic or problem that he approached as an opportunity to "invent".

In 1966 Sid was hired as an Assistant Professor in the newly founded Department of Systems and Industrial Engineering at the University of Arizona in Tucson. This department remained his "home" for 33 years with the exception of brief sabbaticals and leaves such as a National Academy of Science Postdoctoral Fellowship at the Naval Postgraduate School in Monterey, California in 1970-1971.

In 1969 Sid's book *Mathematics of Adaptive Control Processes* (Yakowitz, 1969) was published as a part of Richard Bellman's Elsevier book series. This book was essentially his Ph.D. dissertation and was the first of four published