

Stochastic Modelling for Systems Biology, Second Edition

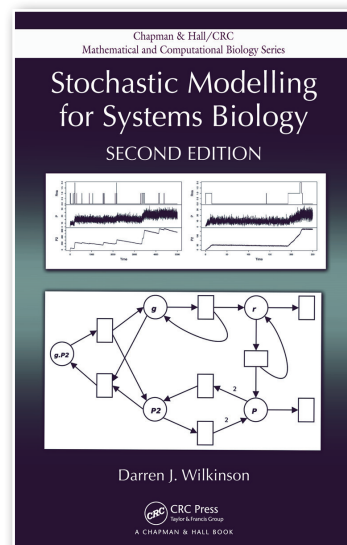


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This book provides an accessible introduction to the use of stochastic processes for modeling biological systems, such as genetic and biochemical networks. This second edition includes improvements to the chapters on kinetics and approximate algorithms. It also greatly expands the coverage of statistical inference, including material on network inference and parameter inference. Updated computing aspects include the use of the new SBML Level 3.

Key Features

- Focuses on computer simulation, with R and SBML code
- Includes exercises and many biologically motivated examples
- Presents enhanced material on statistical inference



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Table of Contents

All Chapters include Exercises and Further Reading

Modelling and networks

Introduction to biological modelling: What is modelling? Aims of modelling, Why is stochastic modelling necessary? Chemical reactions, Modelling genetic and biochemical networks, Modelling higher-level systems

Representation of biochemical networks: Coupled chemical reactions, Graphical representations, Petri nets, Stochastic process algebras, Systems Biology Markup Language (SBML) SBML-shorthand

Stochastic processes and simulation

Probability models: Probability, Discrete probability models, The discrete uniform distribution, The binomial distribution, The geometric distribution, The Poisson distribution, Continuous probability models, The uniform distribution, The exponential distribution, The normal/Gaussian distribution, The gamma distribution, Quantifying "noise"

Stochastic simulation: Introduction, Monte Carlo integration, Uniform random number generation, Transformation methods, Lookup methods, Rejection samplers, Importance resampling, The Poisson process, Using the statistical programming language, R, Analysis of simulation output

Markov processes: Introduction, Finite discrete time Markov chains, Markov chains with continuous state-space, Markov chains in continuous time, Diffusion processes

Stochastic chemical kinetics

Chemical and biochemical kinetics: Classical continuous deterministic chemical kinetics, Molecular approach to kinetics, Mass-action stochastic kinetics, The Gillespie algorithm, Stochastic Petri nets (SPNs) Structuring stochastic simulation codes, Rate constant conversion, Kolmogorov's equations and other analytic representations, Software for simulating stochastic kinetic networks

Case studies: Introduction, Dimerisation kinetics, Michaelis–Menten enzyme kinetics, An auto-regulatory genetic network, The lac operon

Beyond the Gillespie algorithm: Introduction, Exact simulation methods, Approximate simulation strategies, Hybrid simulation strategies

Bayesian inference

Bayesian inference and MCMC: Likelihood and Bayesian inference, The Gibbs sampler, The Metropolis–Hastings algorithm, Hybrid MCMC schemes, Metropolis–Hastings algorithms for Bayesian inference, Bayesian inference for latent variable models, Alternatives to MCMC

Inference for stochastic kinetic models: Introduction, Inference given complete data, Discrete-time observations of the system state, Diffusion approximations for inference, Likelihood-free methods, Network inference and model comparison

Conclusions

SBML Models: Auto-regulatory network, Lotka–Volterra reaction system, Dimerisation-kinetics model

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