Preface

This book originates from my doctoral thesis. One of the first problems of my work was to describe the spread of an infectious disease by a diffusion process and to statistically estimate the involved model parameters. At that time, I did not expect such a seemingly straightforward task to surface so many diverse open problems to fill an entire book. As a mathematician by training, I knew about stochastic calculus, but I did not anticipate the troubles of deriving diffusion approximations and inferring their parameters from real data.

When delving into the diffusion approximation literature, I noticed that there were several, at first sight, contradicting approaches, some of them formulated in generality, others being carried out for particular problems. Their appropriateness, differences and conformities, however, were unclear as well as their extension to more complex, e.g. multidimensional, processes. Furthermore, parameter estimation for diffusions is a challenging problem, in particular if the application of interest involves multi-dimensional processes, few observation times, latent variables and considerable measurement error. Under these circumstances, probably the only applicable technique is a popular Bayesian approach which is used in a number of scientific papers. I was astonished that I could not find any textbook which comprehensively explained it. Moreover, the method has a well-known but hard-to-grasp convergence problem, which has not been detailed in any book or review so far. Since I am convinced that these are subjects of wide-spread interest and importance, I dedicated to them the major chapter in each of the first two parts of this book. The third part finally addresses the initial project which triggered the theoretical questions: to estimate a diffusion model for the spread of diseases.

In contrast to existing literature, this book treats modelling and inference for diffusions under one umbrella. It thus covers both steps that necessarily arise in a real application. Importance is attached to presenting the methods both comprehensibly and mathematically well-founded. As such, the book addresses both theoreticians, like mathematicians and statisticians, as well as practitioners, like bioinformaticians and biologists. The reader is required to have basic knowledge about deterministic differential equations, probability theory and statistics. An introduction to stochastic calculus, in particular to diffusions, is provided in this book.

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