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Book review: Bayesian Theory and Applications

Bayesian Theory and Applications. Editors: Paul Damien, Petros Dellaportas, Nicholas G. Polson & David A. Stephens. Utgiven 2013 på Oxford University Press. 700 sidor.

Though application of Bayesian methods goes back some time, theory of hierarchical models and computational techniques such as Markov Chain Monte Carlo (MCMC) methods have done much to popularize Bayesian techniques among practitioners in diverse areas of applications. This book, a well-balanced collection of papers addressing various applications covers basics as well as current developments in Bayesian theory. So this is definitely a valuable book for statistical practitioners and consultants who like to use a Bayesian framework in their professional work. It gives a reasonable account for researchers too for further investigation; a good book for graduate students to broaden their knowledge. However, it contributes less to, for example, the currently very popular topic of causal inference in statistical studies.

Most of the chapters are written by prominent researchers in the field. The collection is divided into twelve sections, for example, exchangeability, hierarchical models and MCMC. Each of these sections contains around three chapters. The book is dedicated to Sir Adrian Smith, well known for bringing Bayesian methods into mainstream statistical modeling practices. I have selected a few of the chapters for brief commenting, but others are equally attractive to the statistical reader.

In Chapter 1, aleatory uncertainty (objective) and epistemic uncertainty (subjective) are discussed through some examples from finite population sampling where the distinction is rather less precise, and relate them to modeling problems where uncertainty is modeled through the concept of exchangeability. This is a very good starting point for a book on Bayesian statistics. In Chapter 2, a summary account is given of the past work on generalization of exchangeability and de Finetti's theorem in some different settings.

Chapter 3 looks at statistical modeling problems with observational data coming out of different scenarios where experts have different levels of knowledge about the data generating processes. The authors argue that this type of knowledge can be correctly and effectively augmented with real observed data through Bayesian hierarchical models. This makes Bayesian hierarchical models very useful for applied modeling of different scenarios.

The following chapter discusses the so-called kernel based machine learning techniques which are also becoming popular among statisticians. The authors are of the opinion that those are the best possible solutions to the huge flows of data in many settings such as web technologies and various multimedia applications. The authors argue that for many machine learning techniques applied to regression and classification problems use of the full Bayesian framework with predictions that are in forms of posterior probabilities can give better results than usual applications of machine learning techniques. Such models can accommodate a large number of covariates, desirable for large data problems.

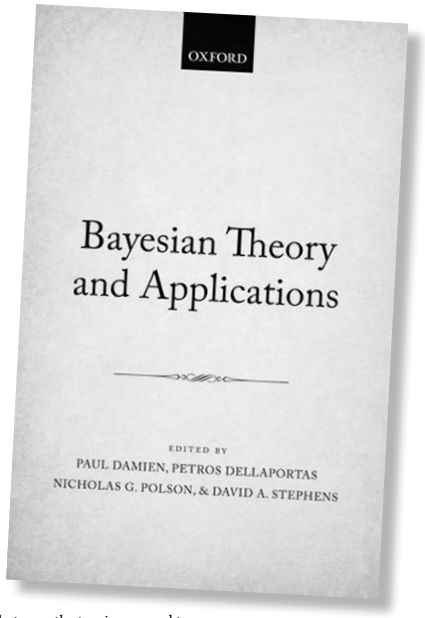
Dynamic models are becoming more and more popular due to the complexity of current inference problems, especially due to their dynamic nature of them. Chapter 8 discusses the basics of dynamic models, nice reading for the applied user, and even for beginners through convincing examples illustrating the relatively simple case of Gaussian assumptions and non–Gaussian cases through a discrete mixture approach. It is a nice introduction to multivariate time series modeling using basic building block type models that are applied in other larger and complex models such as factor and hierarchical models. Another important aspect is looked at in Chapter 9: using information from different sources and fusing them. The authors discuss the important concept of fusing in the context of time series analysis, with special consideration to spatial information modeling. It is an attractive application for the reader.

Though the copula approach for modeling dependence has been around for some time, less attention has been given to a Bayesian approach to it, even though Bayesian methods are prevalent in multivariate modeling contexts. Chapter 17 tries to fill the gap to some extent. Chapter 20 gives a description of Bayesian model specification in a broad sense with some attractive examples. This is a nice piece of work especially for the beginner in statistical modeling. The important problem of variable selection is discussed in Chapters 22 and 23: two contrasting ways of selecting variables are discussed; one excludes the data generating model, which is often a realistic case. However, selection of respective prior model is not convincing as the authors' emphasis is on analytical conveniences and not on the prior knowledge of the model space, if any.

It is shown in Chapter 26 that MCMC can be very useful in tackling problems in finance where evaluation of likelihood is difficult due to the requirement of high-dimensional integration in the presence of latent variables. This is an effective use of the celebrated but unpublished Hammersley–Clifford theorem. A description of credibility theory applied in finance, insurance within Bayesian framework, and current departure of credibility theory from advances in Bayesian statistics are given in Chapter 27. This account is very attractive to a reader interested in applications.

Chapter 28 discusses current developments of Bayesian statistical methods in clinical trials and other biomedical study designs. Due to the complexity of such designs there are many potential problems that can be handled in a Bayesian way. Good references are given for such problems. Another important area is discussed in Chapter 29 in the Bayesian sense; the subgroup analysis. Though it has been shown in the literature that some analytical challenges exist and there are often misleading results from subgroup analysis, particularly in meta-analysis of previously reported clinical studies or even in a single clinical trial study, the authors argue for performing such analyses using Bayesian methods: subgroup analysis as a Bayesian decision problem to avoid such problems. However, they seem to ignore the valuable contextual information in their models.

And in inverse problems, it is tried to recover one thing by observing another where the relationship between the two is assumed to be based on a physical theory; for example, recovering the severity of a potential cause by observing its effect under an assumed causal model in a form of mathematical function. When uncertainties are associated, Bayesian theory gives a nice approach to do this recovery as accurately as possible. Chapter 31 is a good description of current Bayesian practice in inverse problems when observations and beliefs are uncertain. One important thing is how to quantify the propagated uncertainty in the solutions, which is addressed in the chapter to some extent.



All in all, as a statistical researcher I thoroughly enjoyed reading this book. My opinion is that there is a lot to gain from this book, especially for the beginner with a reasonable mathematical background and for the general statistical practitioner.

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