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Bayesian statistics with a smile: A resampling–sampling perspective

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Abstract. In this paper we develop a simulation-based approach to sequential inference in Bayesian statistics. Our resampling–sampling perspective provides draws from posterior distributions of interest by exploiting the sequential nature of Bayes theorem. Predictive inferences are a direct byproduct of our analysis as are marginal likelihoods for model assessment. We illustrate our approach in a hierarchical normal-means model and in a sequential version of Bayesian lasso. This approach provides a simple yet powerful framework for the construction of alternative posterior sampling strategies for a variety of commonly used models.

1 Introduction

Bayesian inference about a parameter θ requires calculating conditional posterior beliefs $p(\theta|y)$ given data y. We assume that the data are generated from a probability model with marginal distribution, $p(y)$, conditional likelihood $p(y|\theta)$ and initial parameter beliefs $p(\theta)$. In most relevant models, the computation of the posterior $p(\theta|y)$, marginal $p(y) = \int p(y|\theta)p(\theta)\,d\theta$ and predictive $p(y_{n+1}|y^n)$ cannot be carried out analytically and approximations are obtained via simulation schemes. In this paper, we provide a simulation-based approximation to both posteriors and marginal likelihoods. We will reverse the logic in the sequential version of Bayes rule to provide a resample-sampling alternative to standard sampling-resample approaches. In this sense, we take the "Bayesian statistics without tears" analogy of Smith and Gelfand (1992) one step further and propose a "Bayesian statistics with a smile" approach to sequential Bayesian inference.

Our new look at Bayes's theorem then delivers a sequential, online inference strategy that should be exploited in the construction of effective posterior simulation schemes. These strategies are intuitive, easy to implement and teach, and deliver more for less as direct approximations to marginal likelihoods are also available. In contrast with Markov chain Monte Carlo (MCMC), our approach is inherently parallel—an important feature as more multiprocessor computational power becomes available.

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