Dissertation

Bayesian Analysis of Nonlinear Time-Series Models

This dissertation consists of three essays in Bayesian time-series analysis. In the first essay, I propose a simple and convenient method for analyzing spatio-temporal data. To account for spatial variability in the data, the mean funcion at each time is written as a loaclly-weighted mixture of linear regressions. Temporal variation is modeled by allowing the regression coefficients to change through time. The model is cast in a Gaussian state-space framework, allowing us to explore temporal factors such as trends, seasonality, and autoregressive components. The main advantage of the proposed method is computational simplicity: through the Kalman filter and smoothing algorithms, posterior and predictive distributions can be obtained in closed form. This allows quick implementation of the model, and provides full probabilistic inference for the parameters, interpolations, and forecasts. To illustrate the method, I analyze two large datasets: one involving tropical rainfall levels and the other Atlantic ocean temperatures. In the second essay, I propose a new Markov chain Monte Carlo (MCMC) smoother for nonlinear, non-Gaussian state-space models. The method can be used to conduct posterior inference in a broad class of dynamic models. The key idea is to construct an approximate state-space model based on mixtures of nomals. This approximation is then used to define the proposal distribution in an efficient Metropolis-Hastings MCMC algorithm, which provides samples from the posterior distribution. To illustrate the method, I consider three simulated examples: an exponential observation model, a stochastic volatility model, and a popular nonstationary growth model. In the third essay, I propose a simulation-based approach to decision theoretic optimal Bayesian design in the context of population pharmacokinetic (PK) models. Depending on the application, these models are also known as repeated measurement models, random effects regression models, longitudinal data models, or population models. I consider the problem of choosing smapling time fo the anticancer agent paclitaxel (Taxol), using criteria related to total area under the curve (AUC), time above a critical threshold, and sampling cost.

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