Bayesian Analysis of A General Class of Multivariate Exponential Family of State Space Models

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Abstract

In this paper, we propose a general class of multivariate exponential family of state space models and consider their Bayesian analysis using particle learning methods. Our proposed model can be considered to be a direct multivariate extension of the class of state space models developed in Gamerman et al. (2013) in the Journal of Time Series Analysis. Unlike most state space time series models in the literature, our proposed model is non-Gaussian that is typically observed in real time series applications in engineering, sciences, finance, and economics. One advantage of state space models is that past correlations are captured by the time evolution of the state parameter, which we refer to as the random common environment. Correlations among multiple series are induced by this random common environment which is assumed to follow a Markovian evolution. For instance, in reliability engineering, several components of the same machine might be exposed to the same common environment (dependence across series) and to the same wear and tear effects of time (dependence over time). In estimating the model parameters, we consider both fully adapted and importance sampling based particle learning methods. In doing so, we provide performance comparisons in terms of both speed of estimation and model fit across several candidates. We argue that for large scale estimation our proposed model provides significantly faster estimation with respect to commonly used Markov chain Monte Carlo (MCMC) methods. To show the implementation of the proposed models, we use several simulation studies and discuss applications in reliability analysis.