MCMC Estimation of Nonlinear Dynamical Systems

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Abstract

We consider the smoothing problem of estimating a sequence of state vectors given a nonlinear state space model with additive white Gaussian noise, and measurements of the system output. The system output may also be nonlinearly related to the system state. It is often not analytically tractable to compute the minimum variance estimate for the state sequence. A Markov chain Monte Carlo (MCMC) method that approximates the minimum variance estimate, as well as confidence intervals, is presented in this talk. The proposal density for this method efficiently draws samples from the Laplace approximation for the posterior distribution of the state sequence given the measurement sequence. This proposal density is combined with the Metropolis-Hastings algorithm to generate realizations of the state sequence that converges to the proper posterior distribution The minimum variance estimate and confidence intervals are approximated using these realizations. Simulations of a fed-batch bioreactor model are used to demonstrate that the proposed method can obtain significantly better estimates than the iterated Kalman-Bucy smoother.