Inverse Modeling of Dynamical Systems

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Conditioning likelihoods are typically much simpler to model than the full joint distribution which may be difficult or impossible to find analytically. Conditioning has the potential to improve the identifiability of the estimation problem. We will quantify various features of dynamical systems, for example, frequency, peak amplitude, inter-peak intervals, phase synchrony, etc. Parameter estimates are often obtained as the minimizers of a loss function which measures departure between the model prediction and the data at each of N points. Estimators with improved prediction bias are obtainable by adding conditional penalties to the loss function. We define a cumulative power penalty and compare its performance to the derivative matching penalty (Ramsay et al, 2007), as well as an optimal weighted average of different methods. The Penalized losses will be included in a Bayesian Markov-Chain Monte Carlo (MCMC) estimation scheme. We provide case studies including a stochastic switching system, neural oscillator (Terman and Wang, 1995) and predator-prey models. We will suggest applications of these methods to wildlife population management, neuroscience, and cryptography.

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