Sequential Monte Carlo for estimating parameters of differential equations

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Abstract

Nonlinear differential equations (DEs), such as ordinary differential equations and delay differential equations, are used in a wide range of scientific problems to model complex dynamic systems. The DEs often contain unknown parameters that are of scientific interest, which have to be estimated from noisy measurements of the DE systems. Generally, there is no closed-form solution for nonlinear DEs, and the likelihood surface for the parameter of interest is often multi-modal and very sensitive to different parameter values. We propose a Bayesian framework for estimating parameters of nonlinear DEs by representing the dynamic process using a flexible nonparametric function to avoid expensive numerical solvers for DEs. We develop an annealed sequential Monte Carlo method to conduct Bayesian inference for parameters in DEs. We demonstrate the usefulness of the proposed methodology through applications to both simulated and real data.