Rare event simulation for steady-state probabilities via recurrency cycles

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Abstract

We develop a new algorithm for the estimation of rare event probabilities associated with the steady-state (stationary) distribution of a Markov stochastic process with continuous, d-dimensional state space and discrete time steps (i.e. a discrete-time R^d-valued Markov chain), e.g. numerical solution to Stochastic Differential Equation. The algorithm, which we coin Recurrent Multilevel Splitting (RMS), relies on the Markov chain's underlying recurrent structure (a concept akin to regeneration), in combination with the Multilevel Splitting method for rare event simulation. The algorithm is simple to use in practice and does not require detailed knowledge of the stochastic process, so that it can be applied to a broad class of systems (including 'black box' models that can be simulated numerically but that are too complex to be studied analytically). Extensive simulation experiments are performed for a 4-dimensional, nonlinear stochastic model that has some characteristics of complex climate models. The results show that RMS can boost computational efficiency by several orders of magnitude compared to the standard Monte Carlo method.

Keywords: rare event, splitting, markov chain, stationary

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