Mathematics > Probability

Rare event simulation for processes generated via stochastic fixed point equations

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In a number of applications, particularly in financial and actuarial mathematics, it is of interest to characterize the tail distribution of a random variable V satisfying the distributional equation V =_D f(V), for some random function f. This paper is concerned with computational methods for evaluating these tail probabilities. We introduce a novel dynamic importance sampling algorithm, involving an exponential shift over a random time interval, for estimating such rare event probabilities. We prove that the proposed estimator is: (i) consistent; (ii) strongly efficient; and (iii) optimal within a wide class of dynamic importance sampling estimators. Moreover, using extensions of ideas from nonlinear renewal theory, we provide a precise description of the running time of our algorithm. To establish these results, we develop new techniques concerning the convergence of stopped perpetuity sequences and the first entrance and last exit times of an associated Markov chain taking values in R. We illustrate our methods with a variety of numerical examples that demonstrate the ease and scope of the implementation.

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