Rare event estimation using sequential directional importance sampling

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We propose a new simulation method, called sequential directional importance sampling (SDIS) for rare event estimation. SDIS expresses the rare event probability in terms of a series of auxiliary failure probabilities, defined by magnifying the input variability. The first probability in the sequence is estimated with Monte Carlo simulation in Cartesian coordinates, and all the subsequent ones are computed with directional importance sampling in polar coordinates. Samples following the directional importance sampling densities used to estimate the intermediate probabilities are drawn in a sequential manner through a resample-move scheme. The latter is performed in Cartesian coordinates and directional samples are obtained through coordinate transformation conveniently. For the move step, two Markov Chain Monte Carlo (MCMC) algorithms are presented for application in low and high-dimensional problems. Finally, an adaptive choice of the parameters defining the intermediate failure probabilities is proposed and the resulting coefficient of variation of SDIS estimator is analyzed. The proposed SDIS method is tested on several examples with various settings, and the results demonstrate that the method outperforms existing sequential sampling reliability analysis methods.