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Title :

Cross-Entropy for the simulation of highly reliable systems, and combination with RQMC methods

The simulation of rare events is required in numerous fields such as performance evaluation and dependability analysis. In this framework, the so-called crude simulation fails since the required average computational time to get only rare event is very large. Speeding-up techniques such as importance sampling have been designed in order to improve those simulation times. Nevertheless, these techniques require some parameter values that are hard to determine a priori. The cross-entropy is a simple and efficient method to dynamically estimate the optimal parameters (see [1] which contains a tutorial on this method as well as an exhaustive list of references), and to solve combinatorial optimization problems.

The goal of this internship is to study this method, to apply it to the simulation of highly reliable (Markovian or not) systems, and to compare the obtained results with the previously used importance sampling methods. The Cross-Entropy technique has already been applied to this type of model, but it requires building a complete transition matrix, which is unlikely to happen for large models. The idea will be here to focus on a restricted class of distributions.

In parallel, it could be interesting to investigate how randomized quasi-Monte Carlo methods could improve the convergence rate to the optimal parameters, based on methods developed in [3,4].

[1] **The Cross Entropy Web Page.** <http://wwwhome.cs.utwente.nl/~ptdeboer/ce/>

[2] A. Ridder. **Importance sampling simulations of Markovian reliability systems using cross-entropy.** *Annals of Operations Research*. Vol. **134**, pp 119-136, 2005.

[3] B. Tuffin. **Randomization of Quasi-Monte Carlo Methods for Error Estimation: Survey and Normal Approximation.** *Monte Carlo Methods and Applications*, Vol. **10**, Num.3-4, pages 617-628, 2004.

[4] P. L'Ecuyer, C. Lécot and B. Tuffin. **A Randomized Quasi-Monte Carlo Method for Markov Chains.** Submitted.