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Title: Why Is Variance Reduction So Important?

Abstract: Monte Carlo simulation is an incredibly versatile tool for studying complex stochastic systems. By replicating the simulation several times independently, one can in principle estimate performances measures of the system to arbitrary accuracy. Decisions and operating rules can also be optimized via simulation. A major drawback, however, is that the method converges very slowly and often requires an excessive amount of computing time.

Efficiency improvement methods provide ways of either reducing the required computing time for a given target accuracy, or obtaining an estimator with better accuracy for a given computational budget. Variance reduction is one way to improve the efficiency. Many key ideas in variance reduction have been introduced already in the early days of the Monte Carlo method, in the late forties, at Los Alamos. But since then, enormous progress has been made in our understanding of these methods.

This talk is a guided tour of some situations where efficiency improvement is essential for the simulation approach to be viable. We will discuss importance sampling and splitting for rare-event simulation, common random numbers and their synchronization for comparing similar systems and for optimization, perturbation analysis for derivative estimation, smoothing estimators by taking conditional expectations, exploiting auxiliary information via control variates, and reducing the noise via stratification and quasi-Monte Carlo. We will provide concrete examples where a clever use of these methods makes a huge difference in the computing time required to obtain a given accuracy.