Center for Computational Engineering Science

RWTH AACHEN UNIVERSITY

Zero-Variance Monte Carlo Schemes

Seminar, Project or Thesis

Project description

Monte-Carlo (MC) schemes are used for many applications, mostly to compute high-dimensional integrals. Applications include Uncertainty Quantification, and particle transport (where the integral equation formulation of the Boltzmann transport equation is solved). The convergence rate of MC schemes comes from the central limit theorem, and is thus fixed at $\frac{1}{2}$. However, MC schemes can be accelerated in practice by variance reduction. This is essentially done by biasing the random experiment toward the desired quantity of interest. In particle transport, this is achieved by so-called weight windows, and the subsequent generation and destruction of MC particles. The choice of these weight windows is often done by hand. However, it can be shown that the weight windows can be extracted from the exact adjoint transport solution. Knowing the adjoint solution, one can construct an exact MC scheme for the forward problem that uses just one particle/random experiment. This is a so-called zero-variance scheme. However, computing the exact adjoint solution is as difficult as solving the exact forward problem. There may be an optimal combination, though, of an inexact (grid-based) adjoint solution, and the corresponding weighted MC particle game.

Possible tasks

- Study the literature zero-variance MC schemes, with applications to radiation transport
- In 1D slab geometry for a simple transport problem:
  - implement MC schemes for the forward and adjoint equation
  - Implement grid-based solvers
  - Perform experiments by combining approximate forward and adjoint solves

Literature

- J.E. Hoogenboom, *Zero-variance Monte Carlo schemes revisited*, Nucl. Sci. Eng. 160 (2008) 1-22.

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