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Solve the Poisson equation with the Multilevel Monte Carlo Feynman-Kac formula

Proposal for a bachelor or master thesis

Scope of Work

This thesis is about the efficient computation of the Feynman-Kac formula with Multilevel Monte Carlo (MLMC) methods to solve the Poisson equation $\triangle u(x) = -g(x)$ with non-constant right hand side. The existing [2] parallel Feynman-Kac MLMC C++ code can solve the Poisson equation with constant right-hand side. The required random walk is generated using the walk on sphere [2] algorithm.

1. The generation of the walk on sphere algorithm on the multiple levels should be derive for non-constant right hand side.
2. The convergence rate of the walk on sphere algorithm in the case of non-constant right hand side should be either measured, derived or found in the literature.
3. The convergence rate (versus work) of the conventional and the Multilevel Monte Carlo Feynman-Kac algorithm should be compared experimentally and if possible theoretically.

Optionally the following tasks could be cosidered:

- Solve a PDE related to an particle accelerator with the MLMC Feynman-Kac algorithm .
- Derive and implement an MLMC approach for the “Single Spherical Atom” [1].
- Derive (or find in the literature) and implement an enhanced load balancing algorithm for random walks.
- You can as well propose other useful extensions.

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Literature

[1] M. Mascagni, Novel Stochastic Methods in Biochemical Electrostatics: (Stochastic Methods for PDEs Can Beat Deterministic Methods), Talk at ETH, 2012.

[2] R. Gantner, Computing the Feynman-Kac Formula Efficiently with Multilevel Monte Carlo, Masterarbeit, Computer Science Department ETH, April 2013

[3] S. Pauli, P. Arbenz, and C. Schwab, Intrinsic fault tolerance of Multi Level Monte Carlo methods, in SAM-Reports, http://www.sam.math.ethz.ch/reports/2012/24, Aug 201

[4] M. Giles, Multi-level Monte Carlo path simulation, Operations Research May/June 2008 vol. 56 no. 3 607-617.