Karlsruher Institut für Technologie

Master's Thesis

Filters For Uncertainty Quantification

Courses: Mathematics, Computer Science, Physics

Topic

A vast amount of physics and engineering applications depend on uncertain measurement data and modeling parameters. The increase of computing power allows researchers to include these uncertainties into simulations in order to check the validity of their results. A commonly used tool to compute quantities such as the expectation value or the variance of the solution is the stochastic Galerkin method. This method yields satisfactory solution approximations in smooth regimes, however exhibits heavy oscillations at shocks.

In this project, we are interested in computing the expectation value and the variance of the state of a gas whose initial state is uncertain. Due to the formation of shocks one needs to find strategies to mitigate oscillations of the stochastic Galerkin method. A promising idea is using filters, since they show non-oscillatory solution approximations while maintaining important solution characteristics. However, several urgent questions remain unanswered:

- Which kind of filter should be chosen for which problem?
- How should one choose the filter strength? Are there strategies which allow an automated choice?
- Can one analytically quantify the effect certain filters have on the solution? If yes, how can this be used to choose an adequate filter strength?

Task

The task of this thesis project is to (partially) answer these questions. The individual steps are:

- Analytically and numerically investigate the filtered stochastic Galerkin system
- Implement different filters and study their effect on the solution
- Find a dimensionless representation of the filter strength

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