Multilevel uncertainty analysis of fluid-structure interaction simulations using adaptive sparse grids

Ionut-Gabriel Farcas*, Benjamin Uekermann†, Tobias Neckel† and Hans-Joachim Bungartz†

* Chair of Scientific Computing in Computer Science (SCCS)
Technical University of Munich
Boltzmannstraße 3, 85748 Garching b. München, Germany
e-mail: farcasi@in.tum.de, web page: http://www5.in.tum.de

† Chair of Scientific Computing in Computer Science (SCCS)
Technical University of Munich
Boltzmannstraße 3, 85748 Garching b. München, Germany
e-mail: {uekerman, neckel, bungartz}@in.tum.de, web page: http://www5.in.tum.de

ABSTRACT

We present a multilevel collocation approach [1] to analyze the uncertainty of computationally intensive applications, such as fluid-structure interactions (FSI). In our scenarios, we model the uncertainty in five input parameters that characterize both fluid and structure.

To propagate the uncertainty, we employ a multilevel approach based on adaptive sparse grid collocation and polynomial chaos approximation (a single level approach was proposed in [2]). Furthermore, we couple the fluid and structure solvers via the partitioned approach. Additionally, we perform all simulations using multiple layers of parallelism.

We implement our multilevel approach as following. One the one hand, to discretize the problem domain, we use a hierarchy of grids whose resolution increases by a constant factor. On the other hand, to discretize the stochastic domain, we employ adaptive sparse grids (see e.g. [3]). With respect to the stochastic domain discretization, our first goal is to control the total number of grid points using adaptive refinement and therefore the total number of runs. Our second goal is to compare the spatial- and dimension-adaptive sparse grids and to test several refinement strategies. Our third goal is to check whether we can reduce the stochastic dimensionality; we compute the total Sobol' indices for global sensitivity analysis and compare them to a user-defined threshold.

Our approach is not restricted to FSI problems. Provided that sparse grids can cope with the stochastic dimensionality, we can approach a large class of computationally intensive applications.

REFERENCES

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