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GLOBAL ERROR ESTIMATION IN CFD MESH COARSENING PROCESS FOR UNCERTAINTY QUANTIFICATION METHODS

Abstract

With modern computers, Uncertainty Quantification (UQ) is becoming an important part of engineering design. Every non intrusive UQ method requires a considerable number of samples (evaluations of the model), meaning that the design process is more expensive in terms of computational resources/time. In Computational Fluid Dynamics (CFD), the usual practice is to reduce the computational time by reducing the number of grid points of the used mesh. Each coarsening of the mesh leads to the increase of the error measured as the difference between the real solution and the solution provided by the computational model. In this work an approach for quantification of the global error, around stochastic domain, in a mesh reduction process is described and results obtained for test cases are detailed.

The method is based on a comparison of the high accurate mesh against coarse mesh with lower accuracy, but less expensive in terms of computational time. The global error is defined as a volume difference between surrogate models created in stochastic domain. The stochastic domain is given by pre-specified input variables with appropriate boundaries. Surrogate models are used and a non intrusive polynomial chaos model is created with response samples from high and low accuracy mesh.

For the chosen test case, the input variables, related to the stochastic space, were the free stream pressure and Mach number. A hypersonic flow solver developed at the Von Karman Institute – Cosmic, was used to compute properties of a flow around the reentry spacecraft. A computational expensive mesh (2 hours for a sample) was used as a reference mesh. Due to computational resources, it was impossible to use expansive mesh for Monte Carlo simulation. Therefore, the global error estimation approach was applied to find an accurate and relatively inexpensive mesh for UQ in hypersonic flight of the spacecraft. Multiple meshes with different coarsening were tested, based on expert knowledge of the problem. The global error estimation method allowed for finding a final mesh with a global error of just 4