

ENSEMBLE UNCERTAINTY QUANTIFICATION

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This presentation addresses the need for the development of uncertainty quantification algorithms that leverage information from one realization to another. Although the size of the computational models used in some weapons calculations is extremely large, i.e. millions of equations, the uncertainty to be analyzed is oftentimes very localized to small regions of the model. One example of this manifests itself in a study of the effects of damping in connections between structural dynamic subsystems. While the full analysis model for this system is on the order of million of degrees of freedom, the nodes involved in an uncertainty analysis of the connection is on the order of ten. Herein, recent efforts to explore, expand, and develop UQ methods that exploit this localization of uncertainty will be discussed.

Algorithms for linear algebraic and dynamic systems have been developed and will be outlined here. In addition, their efficacy will be demonstrated through several examples. These algorithms utilize linear algebra techniques for low rank matrix updates, Sherman-Morrison-Woodbury formulas, and their dynamical analogs.

The computational procedure consists of a small number of full system runs, the number of nodes involved in the connections in the abovementioned scenario. The solutions from this small number of runs are then used to construct a solution update procedure where the remaining computation for each realization involves a system solution of this greatly reduced size. The ratio of the cost of each subsequent realization after these initial calculations to a full system solution is approximately is on the order of the ratio of the number of degrees of freedom of the full system model to that involving uncertainty. Thus, one can expect speedups of several orders of magnitude for the subsequent realizations. In addition, the system updates, due to the small systems being solved, can be performed using a wider variety of computing resources.

It is foreseen that the greatly increased number of realizations can be used to obtain greater fidelity in failure assessments (smaller failure probabilities) and/or to address the epistemic uncertainty issue by considering alternate plausible uncertainty models, including interval models, for the parameters being studied.

Keywords: uncertainty quantification