Hessisches Kompetenzzentrum
für Hochleistungsrechnen

Implementation and Validation of an Approach for Statistical Parameter Calibration



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Clusters
Lichtenberg Cluster Darmstadt

Software
MATLAB

Additional Software
Nastran

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Introduction

The prediction accuracy of models is affected using deterministic parameters. That is because the uncertainty of these parameters is not considered. As part of a master thesis, a calibration method quantifying this kind of uncertainty is selected and applied on a structural dynamic model. During calibration, the model must be evaluated several thousand times, which leads to high computation times. By parallelizing the algorithm and running it on several cores of a high-performance computer, a significant acceleration of the calibration is intended.

Methods

The applied method for statistical parameter calibration is based on the Bayes' theorem. The numerical solution of the theorem is performed by the Transitional Markov Chain Monte Carlo (TMCMC) algorithm. Starting from a simple prior assumption regarding the uncertain parameters, the algorithm allows generating a high number of posterior samples. These samples allow describing the parameters by a distribution instead of a single deterministic value. During calibration, the prior distribution is updated incrementally by adding new data. The calibration is based on maximizing a likelihood function that quantifies the deviation between the new data and the results of the numeric model evaluations. The calibration requires the execution of a high number of model evaluations for different expressions of the uncertain parameters. For automation, a

communication between the algorithm running on MATLAB and the FEM solver is created. Both programs are running on the cluster.

Results

The validation of the implemented method is performed successfully on a FE model provided by an industrial partner. As uncertain parameters, the material parameters Young's modulus and density are selected as part of the data uncertainty. A uniform distribution with upper and lower bounds is used as a prior assumption for the statistical distribution of each parameter. The likelihood is formed for the structural dynamic system from natural frequencies and eigenvectors. The validation is performed by choosing artificial true values unknown to the algorithm. Parallelizing the TMCMC algorithm is showing a great effect on the computing times. Multiple cores of the cluster are utilized running for-loops inside the algorithm on multiple cores. By this measure, the computing time can be reduced from around 6 hours on one core to around 15 minutes on 32 cores.

Discussion

The reduction in computation time achieved is conclusively caused by the for-loop parallelization inside the TMCMC algorithm. However, for complex models with individual long evaluation times, the overall calibration time will remain a significant challenge. A solution approach might be offered by a modification of the algorithm (X-TMCMC), which allows reducing the necessary model evaluations. In addition, measures can be taken to improve the calibration results itself with respect to the convergence behavior (iTMCMC).

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