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The Use of Model Reduction Techniques for Bayesian Finite Element Model Updating

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ABSTRACT

During operation conditions structural systems may deteriorate from a number of reasons. This in turn may affect their performance and reliability. Therefore, the re-assessment of the performance and reliability of a given structure after it has been built by monitoring its response is of paramount importance. In this context, the use of simulation-based Bayesian model updating techniques is explored in this work [1]. The updating information provides more accurate representations of the uncertainties associated with the structural modelling because it is based on both measured data and prior engineering information. The proposed updating methodology is based on measured modal frequencies and mode shapes or dynamic response data.

A simulation based approach called the transitional Markov chain Monte Carlo method is implemented in the present formulation [2]. This technique is computationally very demanding due to the large number of finite element model analyses required. To cope with this difficulty a model reduction technique is implemented to carry out the corresponding analyses efficiently. In particular, a method based on fixed-interface normal component modes plus interface constraint modes is considered in this work [3]. In general, the method produces highly accurate models with relatively few component modes. For certain parameterization schemes the fixed-interface normal modes of each component and the characteristic interface modes are computed only once from a reference finite element model. In this manner the re-assembling of the reduced-order system matrices from components and interface modes is avoided during the updating technique.

The proposed methodology is demonstrated with a series of model updating applications of large finite element models. Validation calculations show that the computational effort for updating the reduced-order model is decreased drastically by two or three orders of magnitude with respect to the unreduced model, that is, the full finite element model. Further computational savings can be obtained by adopting parallel computing algorithms to efficiently distribute the computations in available multi-core CPUs.

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