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VALIDATION & VERIFICATION FOR A METAMODEL OF THE EIGENSOLUTION

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ABSTRACT

The variability of modal quantities, such as eigenfrequencies, modes and damping ratios is of great importance w.r.t. the variability of frequency response functions (FRFs). In addition, the correlations between these quantities highly affect the variability of the FRFs. One possible strategy to explore the influence of the variability of the uncertain structural parameters on the FRFs is to use a metamodel (see, e.g. [1]) for the modal quantities. The established metamodel is a parsimonious mathematical model that approximates the computationally more expensive full model.

Although the increasing computational power of modern computers leads to extensive application of simulation with high fidelity models, metamodeling procedures are still required in many cases to carry out efficiently the structural response evaluation, e.g. for reliability analysis. In fact, for many different applications, e.g. in manufacturing processes, weather forecasting or computer networks administration, the analyst is interested in the establishment of a - possibly simple - mathematical relationship of the input and output in order to obtain fast approximate results of the sought response of interest. In the literature these relations are referred to as supplementary or meta models.

In context with structural analysis the so-called response surface methodology has been applied for reliability analysis. One of the main disadvantages of the response surface approach is its restriction to low-dimensional problems, say to few random variables only. Metamodels, such as polynomial regression, artificial neural networks, splines, kriging or radial basis functions are more suitable for a larger number of random variables. The quality of a metamodel is determined by the following properties [4]:

- Accuracy: capability of predicting the system response in the regime of interest. Besides accurate results for the training set, a good accuracy, too, has to be obtained for the additional control set.
- Robustness: capability to obtain accurate results for as many input parameter combinations as possible.
- Efficiency: computational efforts spent for the set-up of the metamodel.
- Transparency: capability to describe a clear relationship between input and output.
- Conceptual Simplicity: ease of implementation and adaptation for different problems.

It is well known that the variability of many structural response quantities, such as eigenfrequencies or accelerations, generally arises from the variability of few parameters. These parameters are efficiently determined using gradient estimation procedures [2].

This paper addresses the influence of different gradient estimation methodologies for determining the most important uncertain model parameters. Since the presented metamodel for the FRF is a function of several modal contributions, an iterative procedure well suited to evaluate the most influential structural parameters is adopted. Moreover the aspects of validation and verification of the proposed metamodel [3] are discussed. Various examples, from simple analytical functions to complex FE-models, are considered. In figures 1 and 2 the FE-model of a simple truss structure modeled with 43 masses and 136 springs, and the relative importance measures for the eigenfrequency corresponding to mode 14 are shown. It turns out that the iterative gradient estimation procedure is capable to accurately determine the relative importance measures not only for the lowest modes, but also for higher modes. This is a necessary condition in order to use the metamodel for computing FRFs of reasonably complex structures.

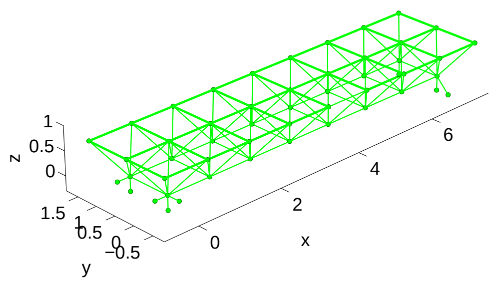

Figure 1: FE-model - truss structure.

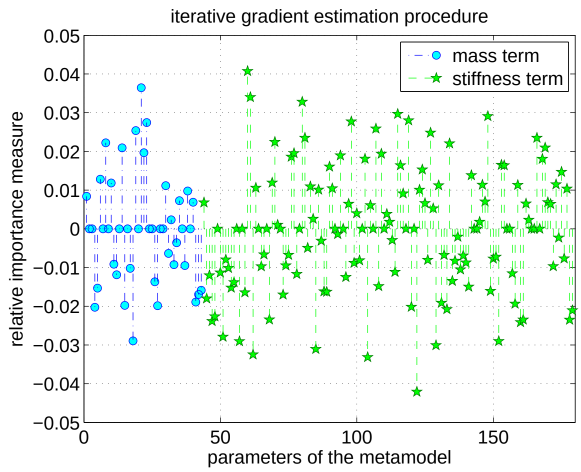

Figure 2: Gradient estimation for mode 14.

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