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Robustness analysis by a probabilistic approach for propagation of uncertainties in a component mode synthesis context

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ABSTRACT

Modelling uncertainties in an industrial application require a thorough knowledge of their sources and types. Uncertainties can be split into aleatory and epistemic types. Using parametric and non-parametric methods successively can be an adapted approach to model these uncertainties types on a given finite elements model (FEM). However, we propose in this paper to proceed more appropriately by introducing a hybrid approach combining the parametric and non-parametric methods. This approach consists of applying, on a given FEM, parametric and non-parametric methods simultaneously with respect to uncertainties types of each model region. Complexity and size of industrial FEMs often impose model reductions. This introduces necessarily the problem of reduction basis robustness. We are interested in the effectiveness of two methods for model reduction in the case of a hybrid model of uncertainties. We consider the case of component mode synthesis (CMS) based on normal modes of clamped interfaces components. Therefore, we analyze robustness of two methods based on improved Craig–Bampton's basis: the first one is enriched by static residual vectors (ESRV), the second one is a variant of the combined approximations method (VCA) adapted to CMS. Finally, a dynamic application on a railway electric motor stator, allows comparing methods' performances in terms of robustness and gain in computing time. Conclusion highlights relevance of the combined approximations method when using a hybrid approach for modelling uncertainties.

1. Introduction

Construction of numerical models to predict the dynamical behaviour of complex assemblies is a real challenge for manufacturers in different industrial areas. Usually, in design step, a numerical model is built in order to predict a mean dynamical response of the system. However, presence of different types of uncertainties can have significant effects on the dynamical behaviour of this model. Consequently, a deterministic mean, or nominal, model is not sufficient to analyze structure dynamics. Robust analysis is usually inevitable during design and it is of a great importance for manufacturers, particularly in railway industry.

Improving robustness analysis depends on the process of identification, modelling and propagating of uncertainties for a studied structure. According to previous works, different uncertainties appellations can be cited [1,2]. Nevertheless one can distinguish epistemic and aleatory uncertainties as two main categories. Epistemic or reducible uncertainties are due to a lack of knowledge in mechanism modelling of some physical phenomena such as interfaces or material behaviour.

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