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Model selection in finite element model updating using the Bayesian evidence statistic

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ABSTRACT

This paper considers the problem of finite element model (FEM) updating in the context of model selection. The FEM updating problem arises from the need to update the initial FE model that does not match the measured real system outputs. This inverse system identification-problem is made even more complex by the uncertainties in modeling some of the structural parameters. Such uncertainty often results in a number of competing forms of FE models being proposed which leads to lack of consensus in the field. A model can be formulated in a number of ways; by the number, the location and the form of the updating parameters. We propose the use of a Bayesian evidence statistic to help decide on the best model from any given set of models. This statistic uses the recently developed stochastic nested sampling algorithm whose by-product is the posterior samples of the updated model parameters. Two examples of real structures are each modeled by a number of competing finite element models. The individual model evidences are compared using the Bayes factor, which is the ratio of evidences. Jeffrey's scale is then used to determine the significance of the model differences obtained through the Bayes factor.

1. Introduction

System identification [17] forms an important stage of many scientific modeling problems and is mainly concerned with the derivation of mathematical models of a system from its measured dynamics. The results from the system identification can then be used to understand and predict the system responses in future designs or different environments. Therefore the analyst is interested in the accuracy, confidence range, and more critically the correctness of the assumed mathematical model.

In this paper, the systems considered are structural and the model domain is that of finite element models (FEMs). In this context, these models are used to approximate the structural dynamics of systems such as train chassis, aircraft fuselages, bicycle frames, or civil structures. It is often the case that the finite element predictions do not match the measured structure's dynamic response [10,12]. This inconsistency may be due to the following: the form of the FE model, the identity and magnitude of the uncertain parameters, the noise and/or errors in the measurements. Furthermore the

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