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Interval model updating with irreducible uncertainty using the Kriging predictor

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ABSTRACT

Interval model updating in the presence of irreducible uncertain measured data is defined and solutions are made available for two cases. In the first case, the parameter vertex solution is used but is found to be valid only for particular parameterisation of the finite element model and particular output data. In the second case, a general solution is considered, based on the use of a meta-model which acts as a surrogate for the full finite element mathematical model. Thus, a region of input data is mapped to a region of output data with parameters obtained by regression analysis. The Kriging predictor is chosen as the meta-model in this paper and is found to be capable of predicting the regions of input and output parameter variations with very good accuracy. The interval model updating approach is formulated based on the Kriging predictor and an iterative procedure is developed. The method is validated numerically using a three degree of freedom mass-spring system with both well-separated and close modes. A significant advantage of Kriging interpolation is that it enables the use of updating parameters that are difficult to use by conventional correction of the finite element model. An example of this is demonstrated in an experimental exercise where the positions of two beams in a frame structure are selected as updating parameters.

1. Introduction

There is increasing interest in improving finite element predictions for industrial-scale structures. Deterministic finite element model updating approaches [1,2] to improving the accuracy of finite element estimates based on inaccurate and variable measured data, are now well-known and widely used in many industries. In most cases experimental variability is supposed not to be inherent in the test structure itself, but arises from other sources such as measurement noise, the use of sensors that affect the measurement or signal processing that might introduce bias. Such variability, termed *epistemic*, is reducible by increased information, e.g. [3]. However, manufacturing and material variability in structures is not reducible and must be considered as part of the model, e.g. [4]. This irreducible uncertainty is termed *aleatory*.

Research on model updating is mostly deterministic in that each of the updating parameters is considered to have one 'true' value and the purpose of the updating process is to provide an estimate of it. In reality nominally identical structures, built to the same design specification, are different, and this difference should be represented in the model as parameter variability. The purpose of model updating then becomes the estimation of ranges or distributions of parameters. Many different methods have emerged to model such variability, generally categorised in two groups: (i) probabilistic and (ii) non-probabilistic. Probability theory and random fields may be used for probabilistic modelling while interval and fuzzy

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