On Bayesian Identification Methods for the Analysis of Existing Structures

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Abstract

The paper explores three stochastic inverse methods based on a functional approximation of the system response: the Markov Chain Monte Carlo method, the Polynomial Chaos Expansion based Kalman Filter, and the parameter update with the Minimum Mean Squared Error estimator. The algorithms were implemented to update the probability distribution function of the input parameters of a finite element model with observable response of the structure. The different methods were tested on a simple case study, where some properties of a concrete water tank from the 60s' were updated. Advantages and drawbacks of each procedure have been discussed according to the obtained results. Attention is drawn on the prospective that the given methods may be applied for better assessing the reliability of existing structures.

Keywords: General polynomial chaos expansion; Bayesian updating; Inverse problem; parameter identification; reliability assessment; existing structures.

1 Introduction

Structural Identification (St-Id) has been defined as the parametric correlation of structural response characteristics predicted by a mathematical model with analogous quantities derived from experimental measurements [1]. In simpler words, St-Id consists in calibrating the features of a model in such a way that the theoretical response of the model matches with the experimental response of the structure.

Models that might be updated can be classified in two main classes: physics-based models, such as mathematical physics and discrete geometric models, and non-physics-based models, listing inter alia numerical, probabilistic and meta models. Discrete geometric models include Finite Element (FE) models, commonly used in structural analysis. Since the response of FE models depends on several parameters, like material constitutive properties, structural scheme, boundary conditions and applied loads, affected by uncertainty. The updating of these parameters is a key issue of the analysis, often performed by means of structural identification methods.

Considering the updating procedure, a direct approach is used if the response of the updated model is expected to match experimental data [2] [3]. Fundamental steps of this method are the definition of an objective function, depending on

https://doi.org/10.2749/stockholm.2016.0116