Quantification of Aleatory Uncertainties in Properties of Heterogeneous Materials

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Abstract

Nowadays the most frequently used building materials typically having heterogeneous micro- and/or meso-structure exhibit variability in their material properties. The uncertainty about their precise morphology cause variations of the structural response under the loading. This phenomenon can be observed during laboratory testing on a set of specimens made of the same material. Parameter identification of a heterogeneous material model can be formulated as a search for probabilistic description of its material parameters providing the distribution of the model response corresponding to the distribution of the observed data , i.e. a stochastic inversion problem.

In the present literature the estimation of aleatory uncertainties is often connected to Bayesian inference based on hierarchical modelling, where some specific shape of probability density function of the model parameters is assumed. It can be defined by a known type of distributions [1] or polynomial chaos expansion [2], but in both cases the estimation of variability is modified to the identification of the hyperparameters of the prescribed distribution which are treated as random variables and represent epistemic uncertainties. Another identification approach uses optimal maps, where the Bayesian inference is based on optimisation of a transformation function between prior and posterior probability distributions, which allows to relax the assumptions about the specific form of the parameters' distribution. Authors in [3] present this approach for quantification of epistemic uncertainties.

This contribution focuses on development of an identification method for aleatory uncertainties connected to the variability in material properties which is based on transformation of the observed quantities into the space of the model parameters.

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References

1. J. B. Nagel and B. Sudret. A unified framework for multilevel uncertainty quantification in Bayesian inverse problems. Probabilistic Engineering Mechanics, Volume 43, January 2016, Pages 68-84, ISSN 0266-8920.
2. C. Soize. A computational inverse method for identification of non-Gaussian random fields using the Bayesian approach in very high dimension. Computer Methods in Applied Mechanics and Engineering, Volume 200, Issues 45–46, 15 October 2011, Pages 3083-3099, ISSN 0045-7825.
3. T. A. El Moselhy and Y. M. Marzouk. Bayesian inference with optimal maps. Journal of Computational Physics, Volume 231, Issue 23, 1 October 2012, Pages 7815-7850, ISSN 0021-9991.