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MULTISCALE ANALYSIS OF BRAIDED COMPOSITES VIA SURROGATE MODELING

Georgios Balokas[1], Steffen Czichon[1] and Raimund Rolfes[2]

[1] Structure Development Department, ELAN-AUSY GmbH,
Harburger Schloßstr. 24, Hamburg, Germany
E-Mails: georgios.balokas@elan-ausy.com, steffen.czichon@elan-ausy.com

[2] Institute of Structural Analysis, Leibniz Universität Hannover,
Appelstraße 9A, Hannover, Germany
E-Mail: r.rolfes@isd.uni-hannover.de

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ABSTRACT

Probabilistic analysis in engineering sciences takes into account the uncertainties that may exist and affect a certain physical system in an a priori unknown manner. As the design of structures gets increasingly complex over the years, the impact of those uncertainties onto the system response has to be studied in order to implement numerical procedures for virtual testing platforms. Especially the variations in the output of a model with regards to some inputs are of much interest. For all the above reasons, quantifying the relative importance of each uncertain input parameter through sensitivity analysis becomes a necessity.

This work implements global sensitivity analysis to study the effect of uncertainties on multiscale analysis of braided composite materials. Several surrogate models (or meta-models e.g. neural networks, polynomial chaos expansions and Gaussian process expansions or Kriging models) are used to overcome the excessive cost of sensitivity analysis for a high-fidelity engineering simulation. Attention is given to non-intrusive approaches and order reduction techniques. The curse of dimensionality is handled through special truncation schemes aiming for a limited set of runs of the original multiscale model. Applicability of the selected modeling techniques is discussed as well as error monitoring and training procedures. All mathematical tools used in this study account for nonlinearities, hence strength prediction is feasible and probabilistic models of failure processes through the scales can also be developed.

Results offer a perspective on the variability influence of the random parameters, an overview of the performance of several surrogate models and also highlight the importance of realistic uncertainty quantification. Moreover, this paper provides a useful guidance for training and handling advanced non-intrusive metamodeling techniques for uncertainty propagation assessment.