11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Surrogate Models for Data-inspired Reliability Design

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Abstract

A design concept called 'Data-inspired Reliability Design', where measured data are aggressively used to improve the accuracy of structural reliability design, is proposed, and surrogate models suitable for this design concept are investigated. When designing the structure of a product, computer simulations for obtaining structural responses are executed under the specific design conditions defined as the different combinations of load, environmental, and operational conditions. In the proposed design concept, the simulation model and design conditions are improved using the measured data for industrial products to be operated appropriately. Since the amount of measured data is limited due to the cost of sensors, the structural responses that are not measured should be predicted using the measured data.

To best use the measured data, the hybrid surrogate models generated using both the measured data and simulation results are applied to predict structural responses in this study. For the hybrid models, the discrepancy between the measured data and simulation results is approximated using response surface methodology [1][2][3]. The Gauss process model and an artificial neural network [4] were used as the response surface, and the suitability of the response surfaces were checked for use as virtual sensors.

To validate the hybrid surrogate models, the structural responses of a welded structure were predicted using both the measured responses and those analyzed using a simulation. The inputs to the surrogate models were the position where the responses were predicted and the applied load to the structure. The applied load history was monitored with sensors during operation; hence the surrogate models could work as a virtual sensor. As a result, the predicted responses agreed well with the measured ones. It can therefore be concluded that using the hybrid surrogate models is one way to predict structural responses instead of using sensors in the proposed design concept.

References

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