MoRePaS 2015

A Model Reduction Approach to Structural Health Monitoring

T. Taddei[1], Y. Maday[2], A. T. Patera[1], J. D. Penn[1], and M. Yano[1]

[1]Department of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, MA, US

[2]Laboratoire Jacques-Louis Lions, Université Pierre et Marie Curie, Paris, France

We present a model reduction approach to the problem of Structural Health Monitoring of systems modeled by parametric PDEs. The approach generates, by exploiting machine learning algorithms and numerical simulations, a classifier that monitors the state of damage of the system.

Our approach is based on an offline/online computational decomposition. In the offline stage, the field associated with many different system configurations, corresponding to different states of damage, are computed and then employed to teach a classifier. In the online stage, the classifier is used to associate measured data to the relevant diagnostic class. In addition, outlier detection schemes can be applied to assess the relevance of the offline model and sampling assumptions.

In order to explore the high-dimensional parameter space associated with the possible system configurations of the undamaged and damaged system, a component-based model reduction technique based on static condensation Reduced Basis Element (scRBE) method is employed. The latter is particularly effective in permitting large variations in geometry (and properties) and also variations in topology.

We illustrate our method through an acoustic duct example: damage is represented as a side hole of variable location and size; both the undamaged and damaged states are subject to uncertainty in wavenumber; input impedance as a function of frequency is chosen as the classification feature.