Spatio-temporal damage identification though Bayesian calibration of time-varying finite element models

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ABSTRACT

Damage identification of civil structures is of primary importance following extreme events such as earthquakes. Detection, location, and quantification of damage provide crucial information to assess the state of health of a structural system. Therefore, it is imperative to develop robust and accurate methods for this purpose. In this paper, an inverse method based on Bayesian inference is proposed to calibrate time-varying finite element (FE) models representing civil structures suffering damage when subjected to seismic excitations. In the two-step approach, the time-varying modal parameters of the structure are identified using recorded input-output seismic vibration data. Then, a linear FE model is developed and calibrated at different time instants of the earthquake by updating the elastic modulus of different elements. The model calibration is conducted by minimizing the misfit between the modal properties (i.e., natural frequencies and mode shapes) using a sequential Monte Carlo inference method. To validate the effectiveness of the approach, a shake table test is carried out on a two-story scaled steel structure with elastomeric bearings at the base, which concentrate the nonlinear behavior of the structure. The results confirmed the good performance of the method in detecting, locating, and assessing the nonlinear behavior in civil structures under seismic loading.