DAMAGE IDENTIFICATION IN STRUCTURAL HEALTH MONITORING AS A BAYESIAN INVERSE PROBLEM

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ABSTRACT

Modern societies heavily rely on efficient and highly available transport infrastructure to provide citizens with goods and services. To keep highway and railway networks fit for service, the monitoring, repair, and replacement of bridges must be ensured—even when financial and human resources are limited. Structural monitoring of bridges, in particular, remains a largely manual process that becomes significantly more time-consuming as structures age and their condition deteriorates. To meet the growing demand for cost-effective monitoring and damage assessment, interpretable digital methods for continuous, sensor-based structural health monitoring are essential.

We start from a mechanical model of a beam-like structure that captures the system's state in response to loads through measurable quantities such as displacements or accelerations. Based on this model, the task of damage assessment—focusing on localization and quantification—is formulated as an inverse problem of parameter estimation. This talk presents a linearized Bayesian inference approach, combining physics-based modeling and scientific machine learning (SciML) methods, to detect deviations in material parameters for damage localization and quantification, along with associated uncertainty measures, thereby enabling the creation of a digital twin [1,2].

We test our method on a numerical benchmark problem involving a two-span beam structure [3]. The benchmark explicitly accounts for variable operational and environmental conditions, such as fluctuations in ambient temperature commonly encountered in bridge monitoring. Furthermore, an extension to real-world sensor data from a measurement campaign on a two-span bridge, including a comparison with baseline operational modal analysis models, is planned [4].

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