Damage Detection for Structural Health Monitoring Under Uncertainty using Deep Interval Neural Networks

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Keywords: *Epistemic uncertainty; Structural health monitoring; Deep neural networks; Machine learning*

Abstract

Structural health monitoring (SHM) is typically concerned with the damage identification and system characterization of engineering structures. Broadly, *damage* is defined as changes to the stiffness of the structural system which compromise its integrity. As sensors do not measure damage directly, the damage detection and identification tasks are performed with indirect methods.

There are two general approaches for detecting and identifying damage in SHM. The first is solid mechanics-based, while the second one is data-centric. The solid mechanics-based approach models the actual structure, usually via a finite element (FE) model, from which the structural responses are obtained. These responses (e.g., displacements, stresses, modes of vibration) are compared with post-processed sensor data to predict whether there is damage. On the other hand, the data-centric approach—used for this work—uses pattern recognition on the sensor data to detect damage with or without the aid of a FE model (depending on the depth of damage identification).

In this work, we consider the problem of SHM real-time damage detection and identification under uncertainty. In SHM systems, uncertainty can be due to environmental factors, sensor malfunctions, unknown sensor placements, miscalibrations, and errors in data acquisition which cumulatively contribute to imprecision in the sensor data. We demonstrate, through a data-centric approach, that deep neural networks with interval uncertainty can be used for SHM damage detection and identification tasks.

The Z-24 bridge dataset is used to test our proposed methods (Reynders and De Roeck (2014)).

References

E. Reynders and G. De Roeck, Vibration-based damage identification: The z24 bridge benchmark, *Encyclopedia of earthquake engineering* 1–8 (2014).