Bauhaus-Universität Weimar

Institute of Structural engineering
Chair of Modelling and Simulation of Structures
Prof. Dr. Guido Morgenthal

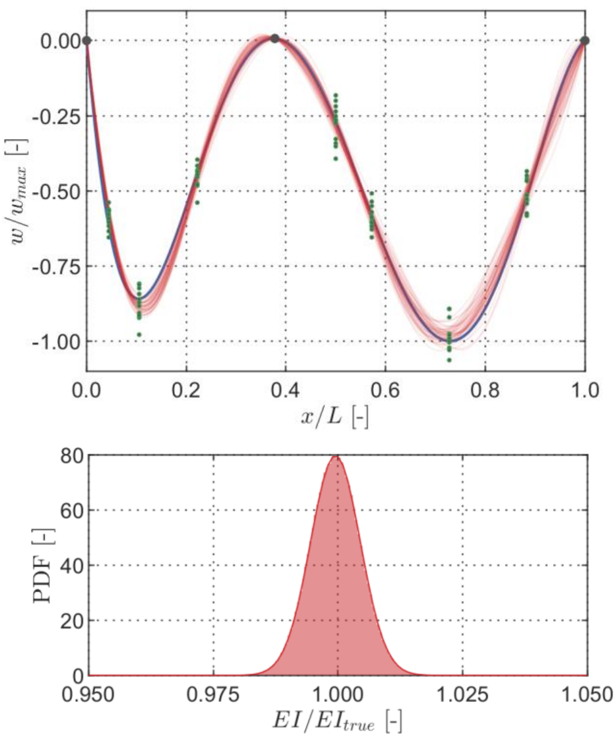
Probabilistic physics informed machine learning models for structural health monitoring

Abstract

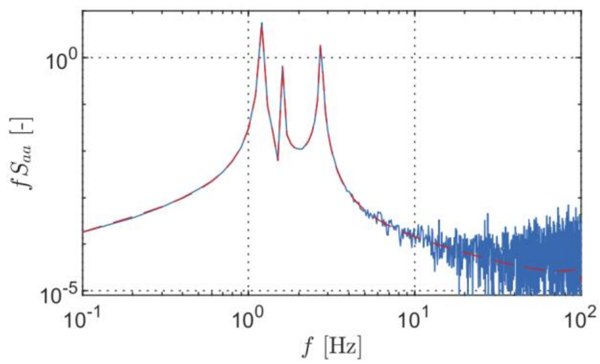
Modern societies are heavily dependent upon engineered structures such as buildings, dams and bridges. Many of these existing systems are now approaching the end of their design life, and maintaining their operational and safety conditions is a task that requires robust reasoning. Moreover, from a climate change perspective, resource efficiency and sustainability are major requirements for the design of new structures. In that manner, an appropriate structural health monitoring (SHM) system supports effective asset management strategies and reduces life-cycle costs.

In the era of Big Data, SHM is commonly carried out through a network of embedded sensors that permanently monitor a structure's condition and response. Thus, a massive amount of heterogeneous information is generally collected by different types of sensors in several positions of a structure, and the challenge converges to the question of how to properly cast this data into knowledge. The natural solution to the problem is the use of artificial intelligence, and more specifically, machine learning models that can be tailored to problem at hand.

In this project, a framework is developed to allow for the identification of the current relevant structural parameters. The physics informed machine learning model is able to suggest optimal locations for sensor placement, in case they are yet to be installed. Heterogeneous measurements, such as deflections, rotations and strains, can also be mutually integrated to determine the quantities of interest. In addition, multi-fidelity datasets are taken into account in a natural manner, where the most relevant datasets are autonomously identified and corrupted or noisy data is automatically ignored by the model.



Top - a sample prediction of the displacement field of a two-span girder bridge. Noisy measured points (•) and noise-less boundary conditions (•) are used as inputs to a probabilistic machine learning model that returns samples of the displacement predictions (——). The finite element model results (——) are shown for comparison. Bottom – the probabilistic model for the identified bridge deck's bending stiffness.



A measured acceleration signal is used as input for a physics informed machine learning model. The power spectral density (PSD) of the predictions (– –) is compared to the PSD or the original noisy dynamic measurement (——).

Contact

Gledson Rodrigo Tondo
Tel.: +49 3643 584427
E-Mail: gledson.rodrigo.tondo@uni-weimar.de

Website

http://www.uni-weimar.de/Bauing/MSK