Lehrstuhl Steuerung, Regelung und Systemdynamik

Master Thesis

programming

Data generation for POD-based evaluation of machine learning-based structural health monitoring techniques

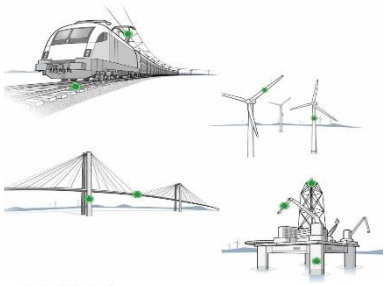
Keywords: structural health monitoring, probability of detection, performance evaluation

Conditions:

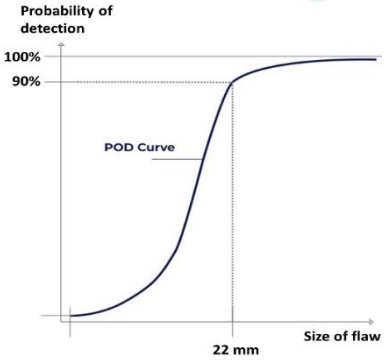
Duration:	6 months
Requirements:	Programming skills in Python or MATLAB, Familiarity with probability and statistics
Language:	English
Target group:	Master students

Contents:

Structural health monitoring (SHM) involves continuous observation of structures using sensor data to detect damages, enabling timely maintenance. Advances in sensor technology and data analytics have led to the widespread use of machine learning (ML)-based SHM techniques in the literature. Unsupervised methods are especially beneficial as they don't require damage-state data during training.



ML-based SHM methods are commonly evaluated using metrics such as accuracy, precision, and error-based measures. However, these metrics do not directly account for process parameters, which are distinct from training/model hyperparameters but influence outcomes. For example, in damage detection, damage size affects the model's ability to perform reliably.



The probability of detection (POD) approach can be used to evaluate ML-based SHM techniques considering process parameters. It is a statistical method that compares monitoring techniques by estimating the likelihood of achieving desired performance under varying process parameter values. Originally developed for evaluating nondestructive testing (NDT) methods, POD-based evaluation produces a curve known as the POD curve. In NDT domain, this curve represents the probability of detecting a flaw as a function of its size, as shown in the figure.

To evaluate ML-based SHM techniques using the POD approach with damage severity as a process parameter, data from various damaged states are needed. However, collecting such data from real structures may not be feasible. While numerical models can generate this data, developing an accurate model for a specific structure can be highly challenging. An alternative approach is leveraging an existing numerical model of a different structure to train generative ML models. The knowledge from these models can then be used to synthesize damaged-state data for the target structure, for different levels of damage. The generated data can be used with an

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unsupervised SHM model, trained on real healthy-state data, to assess its reliability using the POD approach.

The goals of this work are:

- collecting healthy and damaged state data from an existing numerical model
- Training generative ML models to generate damaged state data for the modeled structure
- Using the trained models' knowledge to generate data representing varying damage levels in the target structure
- Verifying if real and generated damaged state data yield similar POD curves for unsupervised damage detection
- Complete and detailed documentation/presentation of the research results

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