Lehrstuhl Steuerung,
Regelung und Systemdynamik

Bachelor Thesis

Literature

Literature Review on Physics-Informed and Data-Driven Methods in Structural Health Monitoring

Keywords: machine learning, structural health monitoring, physics informed ML

Conditions:

Duration:	3 months
Submission until:	30.01.2026
Requirements:	Programming skills in MATLAB
Language:	English/German
Target group:	Bachelor students

Contents:

Structural Health Monitoring (SHM) is a critical field in modern engineering, enabling the early detection of damage, prediction of structural failures, and the extension of service life for engineering assets. Non-destructive testing methods, such as guided waves and Acoustic Emission, provide rich information about material behavior under stress. However, the complexity of wave propagation, environmental variability, and noise make interpretation of the signals highly challenging. Recent advances in data-driven methods have opened new pathways to extract meaningful insights from SHM data. Purely data-driven models often lack robustness and generalization, motivating the integration of physics-informed approaches that embed domain knowledge into learning algorithms. This combined framework has emerged as a powerful tool to improve accuracy, interpretability, and uncertainty quantification in SHM.

The aim of this thesis is to conduct a comprehensive literature review of the current state of the art in SHM, focusing on the intersection of physics-based modeling and machine learning. Special attention will be nonlinear system identification, probabilistic acoustic emission analysis, physics-informed Gaussian processes, and hybrid frameworks for guided wave monitoring. The review will highlight how these methods address key challenges such as environmental effects, uncertainty quantification, and feature extraction from complex ultrasonic signals. The work will also compare traditional model-based approaches with emerging data-driven and hybrid techniques, outlining trends, strengths, and limitations in each. The thesis will synthesize the reviewed literature into a structured framework that can guide future research and applications in SHM.

The goals of this work are:

- Conduct a literature review of traditional SHM approaches using Acoustic Emission
- Analyze state-of-the-art machine learning applications in SHM
- Review the concept of physics-informed machine learning and its application in SHM
- Investigate probabilistic modeling approaches for acoustic emission monitoring
- Compare and contrast purely data-driven, purely physics-based, and hybrid approaches
- Identify open challenges and future research directions for integrating physics-informed methods into SHM
- Complete and detailed documentation/presentation of the research results

Supervisors:	Jonathan Liebeton, M.Sc.	Univ.-Prof. Dr.-Ing. D. Söffker
Office:	MB 351	MB 341
Telephone:	0203/379-3024	0203/379-3429
E-Mail	jonathan.liebeton@uni-due.de.	soeffker@uni-due.de