Physics-aware machine learning of surrogate models for lattice structures

TECHNISCHE UNIVERSITÄT DARMSTADT

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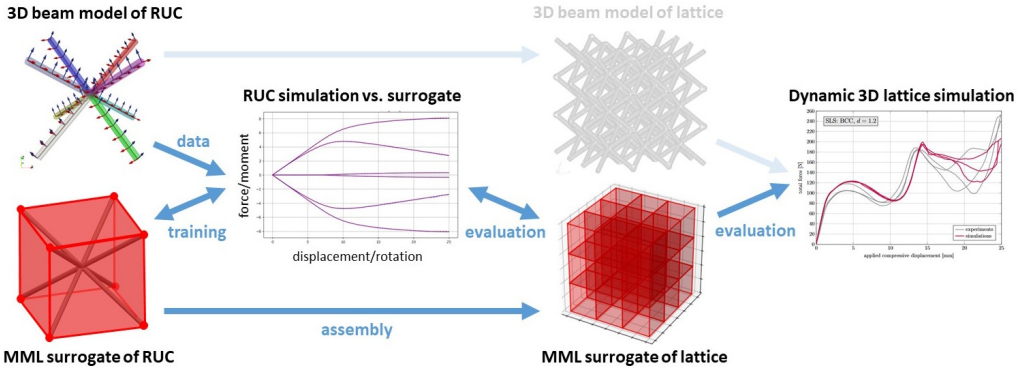

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Introduction

Soft and flexible, additively manufactured lattice structures with tailored and functional dynamic mechanical behavior have significant application potential, e.g., for protection, self-sensing, and actuation devices. However, current research and commercial design tools are limited to elastostatic simulation and optimization capabilities. As multiscale modeling techniques are not applicable for AM structures without scale separation and periodicity, a major challenge is the computational effort associated with the highly nonlinear and dynamic simulation of lattice structures, whether modeled as 3D solids or beams. To this end, physics-aware machine learning (PAML) provides a viable alternative to obtain computationally efficient, yet accurate and reliable, thermodynamically consistent dynamic surrogate models. Such PAML-based surrogate models could facilitate rapid computational design, optimization, and uncertainty quantification of flexible lattice structures.

Potential topics

- Develop **nonlinear surrogate models** for lattice cells using PAML approaches such as port-Hamiltonian NNs, GENERIC, autoencoders, graph NNs, operator learning, etc.
- Combine lattice unit cell surrogates into a **dynamic structural model** that can be efficiently simulated
- Parameterize surrogate models in terms of lattice unit cell **design variables** such as cell types, diameters, material properties, etc.
- Extend surrogate models from purely elastic to **dissipative material behaviors** such as plasticity, visco-elasticity, or damage