ETH
Eidgenössische Technische Hochschule Zürich
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Master Thesis

Data-driven prediction of path-dependent response of architected truss metamaterials

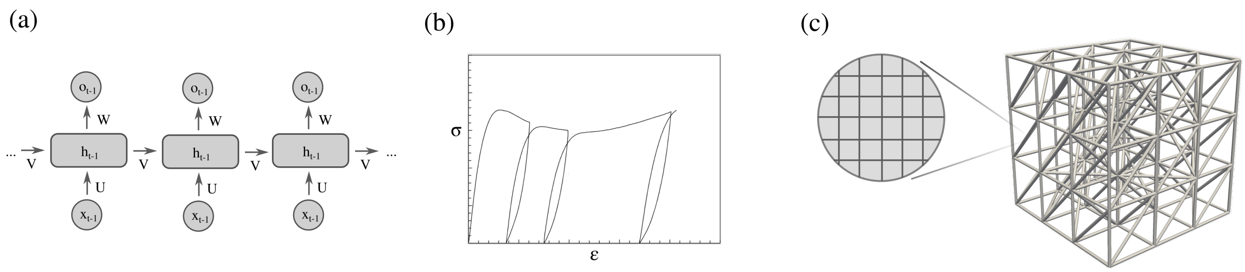

Figure 1: a) Recurrent neural network architecture. b) Stress-strain response of polycarbonate undergoing tensile cyclic loading. c) Truss lattice and cross-section of beam member.

Description: Architected truss materials can nowadays be additively manufactured from a wide range of materials (e.g. polymers, metals), which often exhibit rate- and path-dependent effects induced by viscoplastic, damage, hardening and other processes. Conventional modeling of these complex systems relies on fully resolved calculations using ad-hoc constitutive laws. However, these laws are typically phenomenological, they can be notoriously hard to calibrate, and do not guarantee capturing the complexity of the mechanical response.

This project concerns the development of a reduced-order *data-driven* physics– and thermodynamics–informed algorithm for predicting the response of truss lattices while circumventing the need for a conventional constitutive law. Restricting the scope to slender beam systems, and focusing on the beam-level response (Fig. 1 b,c), we avoid the complexity related to directly modeling the three-dimensional constitutive behavior of the lattice. The student will develop machine learning algorithms such as recurrent neural networks (Fig. 1 a) (e.g. long short-term memory (LSTM) or gated recurrent unit (GRU) architectures) [1] which describe the state or memory of the material, or thermodynamics-based neural networks, which explicitly describe the dissipation potential. Direct data-driven computing prediction of the response with explicit incorporation of thermodynamic constraints [2] will also be considered. The reduced-order nature of the developed model will effectively avoid the requirement for vast amounts of training data from experiments.

Tasks:

- Development and implementation of data-driven algorithm
- Application of the algorithm to modeling of architected truss lattices

Prerequisites:

- Background in mechanics and/or computational science
- Good computer coding skills (Python, C++)

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References

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[2] K. Karapiperis, L. Stainier, M. Ortiz, J. Andrade, Data-driven multiscale modeling in mechanics, Journal of the Mechanics and Physics of Solids (2020) 104239.