
On the role of interpretability of data-driven constitutive modeling by constitutive artificial neural networks

Kian Abdolazizi*¹, Christian Cyron^{1,2}, and Kevin Linka¹

¹Hamburg University of Technology – Germany

²Helmholtz- Zentrum Hereon – Germany

Abstract

The classical theory-driven approach to describe the deformation of a material body is based on the formulation of constitutive equations relating strains and stresses. A drawback of this approach is the effort typically required to develop appropriate functional relations and to identify material parameters. These efforts are not required in data-driven approaches to constitutive modeling. To combine the advantages and overcome the disadvantages of both theory-driven and data-driven constitutive modeling, we have developed the novel concept of Constitutive Artificial Neural Networks (CANNs) (1, 2). This machine learning approach to data-driven constitutive modeling does not require any major a priori assumptions about the constitutive law, but still incorporates substantial theoretical knowledge of continuum mechanics and constitutive theory. In this way, CANNs are able to learn the constitutive law of a material from relatively small amounts of stress-strain data. Moreover, our results suggest that CANNs can robustly discover different flavors of material models from data and, by design, have a clear physical interpretation. These capabilities are illustrated using different data collected from arterial and brain tissue.

- (1) K. Linka, M. Hillgärtner, K.P. Abdolazizi, R.C. Aydin, M. Itskov, C.J. Cyron, Constitutive artificial neural networks: A fast and general approach to predictive data-driven constitutive modeling by deep learning, *Journal of Computational Physics*, 429:110010, 2021.
- (2) K.P. Abdolazizi, K. Linka, C.J. Cyron, Viscoelastic constitutive artificial neural networks (vCANNs) – A framework for data-driven anisotropic nonlinear finite viscoelasticity, *Journal of Computational Physics*, 499:112704, 2024.

*Speaker