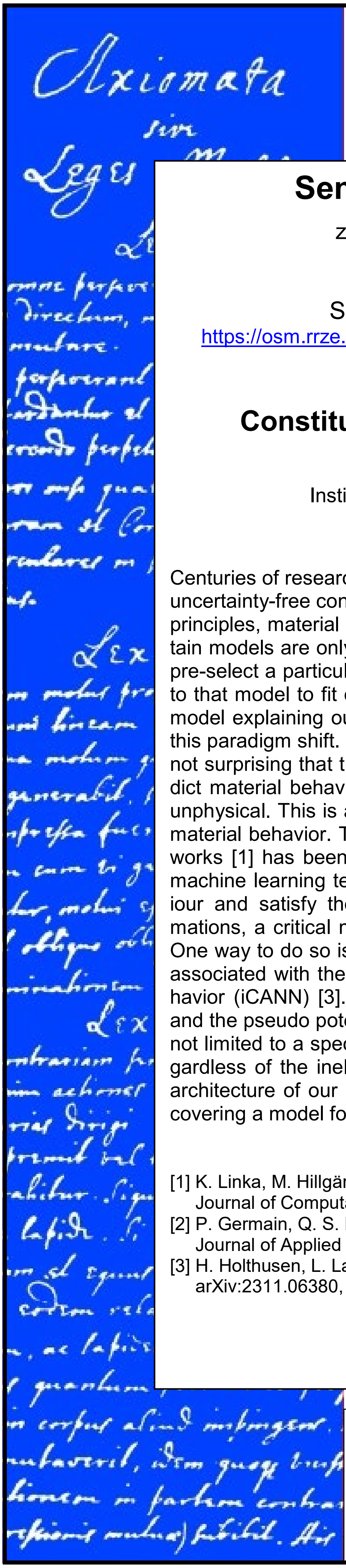

Friedrich-Alexander-Universität
Technische Fakultät

Seminar über Fragen der Mechanik

zu folgendem Vortrag wird herzlich eingeladen

Donnerstag, 18.04.2024, 14:00 Uhr

Seminarraum EL 4.14, Cauerstr. 7-9, 4. OG
https://osm.rrze.fau.de/map-ll-osm?mlat=49.573444&mlon=11.029140&zoom=17

Material discovery with inelastic Constitutive Artificial Neural Networks (iCANNs)

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Centuries of research in the field of physics and mechanics have guided us towards the uncertainty-free conversational laws in continuum mechanics for solids. Following these principles, material models have been derived that obey these laws. Unfortunately, certain models are only able to explain a specific material behavior. In practice, we usually pre-select a particular model and try to find the best material parameters corresponding to that model to fit our data; instead, it is our strong belief that we should find the best model explaining our data. This is where machine learning algorithms help us achieve this paradigm shift. Since these algorithms lack from knowledge of thermodynamics, it is not surprising that they learn the data used for training very well, but their ability to predict material behavior outside the training regime is disastrous and, most of the time, unphysical. This is already the case for elastic materials and is even worse for inelastic material behavior. To overcome this issue, a family of Constitutive Artificial Neural Networks [1] has been developed that combines thermodynamic knowledge with modern machine learning techniques. These networks are designed for elastic material behaviour and satisfy thermodynamics a priori. As most materials exhibit inelastic deformations, a critical missing link is to expand the general concept to inelastic materials. One way to do so is to introduce a pseudo potential depending on stress-like quantities associated with the inelastic rate [2]. Here, we extend CANNs to inelastic material behavior (iCANN) [3]. Therefore, our network discovers both the Helmholtz free energy and the pseudo potential, which explain the experimental data the best. As the design is not limited to a specific inelastic phenomenon, thermodynamics are satisfied a priori regardless of the inelastic behavior. For illustrative purposes, we specialize the general architecture of our iCANN to visco-elasticity and demonstrate that it is capable of discovering a model for polymers and skeletal muscle data.

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[2] P. Germain, Q. S. Nguyen, and P. Suquet, Journal of Applied Mechanics 50, 1010-1020 (1983).
[3] H. Holthusen, L. Lamm, T. Brepols, S. Reese, and E. Kuhl, arXiv:2311.06380, https://doi.org/10.48550/arXiv.2311.06380 (2023).

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