nanoSeminar Series 2021

Institute for Materials Science

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Chair of Comp. And Exp. Solid Mechanics, TU Dresden, Germany

“Automated Constitutive Modeling Of Isotropic Hyperelasticity Based On Artificial Neural Networks”

Thursday, March 25th 2021
13:00 – 14:00

Normal: Seminar Room 115, Hallwachsstr. 3 (HAL)

Pandemic version: https://tinyurl.com/nanoSeminar-GA

The formulation and parametrization of constitutive equations is still a challenging task for materials which reveal complex behavior such as highly nonlinear elasticity, anisotropy or dissipative properties. Due to this, numerous novel approaches – generally referred to as data-based or data-driven methods – have arised recently [1]. These methods circumvent the classical constitutive modeling by directly using data in finite element computations, constructing constitutive manifolds or using artificial neural networks (ANNs).

In this contribution, an automated ANN-based strategy for the efficient description of isotropic hyperelastic solids is presented. Starting from a large data set comprising deformation and corresponding stresses, a simple, physically based reduction of the problem’s dimensionality is performed in a data processing step. More specifically, three deformation type invariants serve as the input instead of the deformation tensor itself which is similar to Liang and Chandrashekhara [2]. In the same way, three corresponding stress coefficients which are derived from the stress-strain tuples replace the stress tensor in the output layer. Using the reduced data set, a constitutive ANN is trained by using standard machine learning methods. Furthermore, in order to fulfill the thermodynamic laws, the previously trained network is modified by constructing a pseudo potential within an integration step and a subsequent derivation.

The proposed method is exemplarily shown for the description of a highly nonlinear Ogden type material in several demonstrative examples. Thereby, the necessary data sets are collected from virtual experiments of a discs with holes. Influences of different loading types and specimen geometries on the resulting data sets are investigated in a systematic study. The developed approach is applied on thevirtually generated data set. Thereby, an excellent approximation quality could be achieved for training,test and validation data with only one hidden layer comprising a comparatively low number of neurons.Finally, the application of the trained constitutive ANN for the simulation of more complex samples verifies the capability of the method.

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Karl Kalina studied mechanical engineering at TU Dresden from 2009 to 2015, whereby he specialized on applied mechanics in the main courses. From 2016 to 2021 he worked on the modeling and finite element simulation of magnetorheological elastomers at multiple scales within his PhD at the chair of Computational an Experimental Solid Mechanics leaded by Prof. Markus Kästner. In the beginning of 2021 Karl started to lead his own subgroup at the chair which focuses on the data-driven constitutive modeling of solid materials within a continuum mechanical framework.

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