A model-free data-driven approach for plasticity.

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ABSTRACT

The amount of data available is increasing every day. Data science has not only a big impact on social media or sales analysis applications, but also in engineering areas. Experimental measurements get more reliable and data-rich. Consequently, research in mechanics has started to concentrate more and more on data-driven modelling. In our work we want to use data from experiments to extract pairs of stress and strain to execute computations by evaluating them directly. Hereby, we bypass the step of constitutive modelling, thus, any kind of modelling error as well as any problem concerning parameter fitting.

The authors have extended the formulation initially introduced in [1] to in principal any kind of inelasticity [2]. Material behavior which shows a path-dependence can always be described by a function of previous deformations. Further, many materials show a fading memory property. That means their behavior is more related to the shorter history. For example plastic materials with kinematic hardening can be described only by data tuples of $(\boldsymbol{\varepsilon}_{k+1}, \boldsymbol{\sigma}_{k+1}, \boldsymbol{\varepsilon}_k, \boldsymbol{\sigma}_k)$, where $(\bullet)_{k+1}$ describes a measured quantity in one time step and $(\bullet)_k$ the quantity in a previous time step.

As a first step, the theory is explained by simple one-dimensional examples for truss structures. In practice, the value of this data-driven formulation for inelasticity is measured on how it can deal with extracted data from experiments e.g. by digital image correlation (DIC) [3]. Focusing on plasticity we show further examples for multi-dimensional computations.

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