Gebhardt, Cristian Guillermo; Schillinger, Dominik; Steinbach, Marc Christian; Rolfes, Raimund


Summary: Data-Driven Computational Mechanics is a novel computing paradigm that enables the transition from standard data-starved approaches to modern data-rich approaches. At this early stage of development, one can distinguish two mainstream directions. The first one, which can be classified as a direct approach, relies on a discrete-continuous optimization problem and seeks to assign to each material point a point in the phase space that satisfies compatibility and equilibrium, while being closest to the data set provided. The second one, which can be classified as an inverse approach, seeks to reconstruct a constitutive manifold from data sets by manifold learning techniques, relying on a well-defined functional structure of the underlying constitutive law. In this work, we propose a hybrid approach that combines the strengths of the two existing directions and mitigates some of their weaknesses. This is achieved by the formulation of an approximate nonlinear optimization problem, which can be robustly solved, is computationally efficient, and does not rely on any special functional structure of the reconstructed constitutive manifold. Additional benefits include the natural incorporation of kinematic constraints and the possibility to operate with implicitly defined stress-strain relations. We discuss important mathematical aspects of our approach for a data-driven truss element and investigate its key numerical behavior for a data-driven beam element that makes use of all components of our methodology.

MSC:
74S05 Finite element methods applied to problems in solid mechanics
65N30 Finite element, Rayleigh-Ritz and Galerkin methods for boundary value problems involving PDEs
74Bxx Elastic materials
74P10 Optimization of other properties in solid mechanics

Keywords:
data-driven structural analysis; finite element method; constitutive manifold; general elasticity; approximate nonlinear optimization problem; geometrically exact beam

Software:
HYPLAS

Full Text: DOI

References:


This reference list is based on information provided by the publisher or from digital mathematics libraries. Its items are heuristically matched to zbMATH identifiers and may contain data conversion errors. It attempts to reflect the references listed in the original paper as accurately as possible without claiming the completeness or perfect precision of the matching.