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EUCLID: Efficient Unsupervised Constitutive Law Identification and Discovery

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We propose a new approach for data-driven automated discovery of constitutive laws in continuum mechanics. The approach is unsupervised, i.e., it requires no stress data but only displacement and global force data, which can be realistically obtained from mechanical testing and digital image or volume correlation techniques; it can deliver either interpretable models, i.e., models that are embodied by parsimonious mathematical expressions, or black-box models encoded in artificial neural networks; it is one-shot, i.e., discovery only needs one experiment - but can use more if available. The machine learning tools enabling discovery are sparse regression from a large model space, as well as Bayesian regression, which allows for the discovery of several constitutive laws along with their probabilities. After discussing the methodology, the talk illustrates its applications to hyperelasticity, plasticity and viscoelasticity, using both artificial and experimental data.