LMS Seminar

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EUCLID: Learning constitutive models without stress data

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ABSTRACT

Despite the recent advances in data-driven methods, constitutive modelling of materials remains embedded in a supervised setting where the stress-strain pairs are assumed to be available. However, in most common experimental setups, it is difficult to probe the entire stress-strain space, while getting such labelled data is expensive via multiscale simulations. The biggest challenge is – how does one even measure full stress tensors (forces are only boundary-averaged projections of stress tensors) for learning the stress-strain relations?

To bypass these challenges, we recently proposed a new data-driven framework called EUCLID which stands for – Efficient Unsupervised Constitutive Law Identification and Discovery (https://euclid-code.github.io/). The approach is unsupervised, i.e., it requires no stress data but only displacement and global force data, which are realistically available through mechanical testing and digital image correlation techniques. The problem of unsupervised discovery is solved by leveraging physical laws such as conservation of linear momentum in the bulk and at the loaded boundary of the domain. We discover physically interpretable models embodied by either – (i) parsimonious mathematical expressions discovered through sparse regression of a large catalogue of candidate functions, or (ii) ensemble of physics-consistent neural networks with higher generalization capability at the cost of analytical treatment. We demonstrate several benchmarks on the discovery of hyperelastic and elastoplastic constitutive models without using any stress data.

BIOGRAPHY

Sid Kumar is an Assistant Professor at TU Delft in the Department of Material Science and Engineering since 2021. He obtained his Ph.D. in Aeronautics from Caltech in 2019 followed by a postdoc position at ETH Zürich. Previously, he obtained a dual M.S. in 2017 from Caltech in Aeronautics and Ecole Polytechnique (France) in Multiscale and Multiphysics Modeling, and a B.Tech. in Mechanical Engineering from IIT Delhi in 2014. He received the Foster and Coco Stanback fellowship in Engineering and Applied Science at Caltech and the University of Paris Saclay fellowship at Ecole Polytechnique. His research interests lie at the intersection of mechanics of materials, computational modeling, and machine learning — with a focus on inverse problems in (meta-)material design and modeling.