TITLE: *Model-Free Data-Driven Computing: Theory and Practice*

ABSTRACT

We present a model-free Data-Driven framework for multiscale analysis of inelastic materials. The aim of the framework is to enable predictions of structural response directly from data gleaned at the micromechanical level, without the intermediate step of modeling the micromechanical data. A distinguishing aspect of the formulation is that it is internal-variable free, i.e., it does not require the identification of actual or ad hoc (learned) internal variables. Instead, the inelastic macroscopic response and its evolution is characterized by defining a dissipation connection in macroscopic phase space. We show how the phase field can be sampled, and the dissipation connection identified, directly from micromechanical calculations on representative-volume elements (RVEs). The data is reusable over a broad range of boundary-value problems and loading conditions involving the same material. Solutions to specific boundary-value problems can then be obtained by minimizing a distance from the material sample to the set of equilibrium and compatible states and, in a time-discrete setting, by simultaneously minimizing the incremental dissipation. We demonstrate the framework by means of an application concerned with the prediction of the behavior of sand, a prototypical complex history-dependent material. Data is generated by direct simulation of large ensembles of grains. The approach is able to predict the material response under complex non-monotonic loading paths, and compares well against plane strain and triaxial compression shear banding experiments.