A Thermodynamic-Consistent Reduced-Order Machine Learning Model for Non-Equilibrium Materials Response

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Abstract

The materials loading response beyond elastic region usually exhibit a complex history dependency rising from its heterogeneity and the nature of plasticity, rendering huge modeling difficulties in both theoretical and computational aspects. In order to avoid such history dependency, a reduced-order model can be developed by introducing extra internal variables such that the materials loading response can be fully determined by the loading condition and internal variables at current step. However, despite of the model simplicity, internal variables usually cannot be measured directly from experiment. In this work, we propose a thermodynamic-consistent machine learning architecture to learn this reduced-order model from the materials loading responses (such as stress-strain curves) without any knowledge of internal variables. Such a model was verified on various examples including viscoelasticity and crystal plasticity. It can also be utilized as a constitutive law for doing simulation in a larger scale.

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