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A NEW FINITE STRAIN REDUCED ORDER MULTISCALE FORMULATION FOR POLYCRYSTALLINE MATERIALS

Damin Xia[1] and Caglar Oskay[2]

[1] Vanderbilt University, Nashville TN 37235, USA, damin.xia@vanderbilt.edu
[2] Vanderbilt University, Nashville TN 37235, caglar.oskay@vanderbilt.edu, URL: https://my.vanderbilt.edu/mcml/

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In this study, we present a novel reduced-order multiscale formulation for analysis of structures made of polycrystalline materials undergoing large deformations [1]. The proposed formulation leverages the compututational homogenization approach, where asymptotic analysis with multiple scales is employed to decompose the original governing equations into a microscopic problem defined over the characteristic volume (i.e., representative or statistical volume element) and a macroscopic problem defined over the structure. The model order reduction is achieved by generalizing the principles of Eigenstrain-based reduced order homogenization (EHM) [2,3]. Model order reduction is applied on the microscopic problem by employing the idea of representing the inelastic deformation rate using influence functions and a coarse basis approximation of the microscale kinematics. At the microstructural scale, the deformation behavior within the characteristic volume is idealized using a crystal plasticity constitutive law. The incremental constitutive form is approximated using a two-term Taylor series expansion, which allows us to express the rate of deformation as a function of two sets of influence functions, similar in form to the small-strain EHM theory.

An efficient implementation scheme is proposed to evaluate the multiscale system without the need to recompute the reduced basis as a function of evolving deformation. The accuracy and efficiency characteristics of the reduced order model in capturing homogenized and localized behavior as well as texture evolution is demonstrated by comparing with crystal plasticity finite element simulations in the context of single crystal and polycrystal microstructures. Numerical verification studies demonstrate that the proposed approach efficiently and accurately captures the overall as well as local mechanical response of the microstructure.

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