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Investigating plastic anisotropy using crystal plasticity and deep learning models

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Traditional methods of characterizing plastic anisotropy in metal alloys require iterative experiments or high-fidelity computational simulations. To avoid expensive anisotropy characterization procedures, a novel data-driven anisotropy prediction model is developed from a large dataset of crystal plasticity (CP) calculations. A deep learning (DL) model was trained by a ~55,000 analytical CP calculations of normalized yield stresses and plastic strain increments. The validity and accuracy of the DL model was assessed by additional 20,000 validation dataset from CP calculations. Quantitative comparisons of CP and DL predictions of yield stresses and lateral strain ratios show that the DL model accurately and efficiently links material's initial crystallographic texture to plastic anisotropy. DL-based predictions were further assessed by performing finite element simulations of cup drawing using the non-quadratic yield function parameterized from CP, CP-FEM and DL anisotropy predictions. The DL-based simulation showed excellent agreement CP and CP-FEM, demonstrating that accurate anisotropy information was obtained without the need of performing expensive high-fidelity simulations.

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