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Detecting Plasticity in Material Mechanical Deformations through Digital Image Correlation and Unsupervised Machine Learning

Digital image correlation (DIC) stands out as a powerful technique, providing a visual representation of strain maps during mechanical deformation while generating extensive data at every pixel, revealing surface strain components [1]. The true potential within this dataset is unveiled through materials informatics, seamlessly incorporating advanced statistical and machine learning methodologies. However, challenges arise when a comprehensive understanding is lacking, potentially leading to overfitting artifacts and unsuccessful machine learning training. To address this concern, the utilization of unsupervised machine learning techniques, exemplified by principal component analysis (PCA), proves to be insightful in navigating these complexities and can be used extracting valuable information from DIC strain data [2, 3].
In our study, we investigate inferring the mechanical properties of materials solely using local strain information produced by DIC with the use of our developed techniques based on unsupervised ML. As an example, we demonstrate the detection of the transition to the plastic deformation stage and prediction of plasticity localization using experimental DIC data from “creep” and “uniaxial tension” mechanical tests, as well as synthetic data from nano-indentation simulations.

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