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Computer Vision Approaches for Segmentation of Nanoscale Precipitates in Nickel-Based Superalloy IN718

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Obtaining accurate volume fraction and size measurements of γ'' and γ' precipitates in Ni-base superalloys from scanning electron microscopy images is challenging and conventionally involves manual image processing due to their smaller size, similar crystal structures, and chemistries. The co-precipitation of composite particles further complicates automated segmentation. In this work, as the first step, an automated image processing algorithm, based on fast radial symmetry, was developed that achieved 94% segmentation accuracy. The algorithm was used as an annotation tool to label pixels in images as "ground truth" for training three machine learning algorithms that skip the human-in-the-loop branch in the training process. The objective was to increase usability and optimize the computer resources without sacrificing annotation accuracy. Different types of traditional machine learning approaches and a convolutional neural network (CNN) were compared with the initial image processing algorithm, for the segmentation of the composite particles of γ'' and γ' precipitates. The data set contains 47 experimentally generated scanning electron micrographs of IN718 alloy samples, computationally increased to 188 images (900×900 px). All algorithms are containerized using singularity, publicly available, and can be modified without dependencies. The CNN and the random forest models achieve 95% and 94% accuracy, respectively, on the test images with better computational efficiency than the non-machine learning algorithm. The CNN tested accurately over a range of imaging conditions, indicating that the approach is robust to variability resulting from human biases in data collection.