Multitask Learning of Scanning Electron Microscopy and Synthetic Thermal Tomography Images for Detection of Defects in Additively Manufactured Metals

Sarah Scott
Advisor: David Carlson
Duke University
srs108@duke.edu

Abstract:

One of the key challenges in laser powder bed fusion (LPBF) additive manufacturing of metals is the appearance of microscopic pores in 3D printed metallic structures. Quality control in LPBF can be accomplished with nondestructive imaging of the actual 3D printed structures. Thermal tomography (TT) is a promising non-contact nondestructive imaging method, which allows for visualization of subsurface defects in arbitrary size metallic structures. However, because imaging is based on heat diffusion, TT images suffer from blurring, which increases with depth. We have been investigating enhancement of TT imaging capability using machine learning. In this work, we introduce a novel multi-task learning (MTL) approach, which simultaneously performs classification of synthetic TT images, and segmentation of experimental scanning electron microscopy (SEM) images. Synthetic TT images are obtained from computer simulations of metallic structures with subsurface elliptical-shape defects, while experimental SEM images are obtained from imaging of LPBF-printed stainless-steel coupons. MTL network is implemented as a shared U-net encoder between the classification and the segmentation tasks. Results of this study show that the MTL network performs better in both the classification of synthetic TT images and the segmentation of SEM images tasks, as compared to conventional approach when the individual tasks are performed independently of each other.