Title:
Training deep neural networks to reconstruct nanoporous structures from FIB tomography data using synthetic training data

Keywords:
Electron microscopy, Synthetic training data, 3D reconstruction, Semantic segmentation, SEM simulation, 3D CNN, 2D CNN with adjacent slices, machine learning

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Abstract of the paper:
Focused ion beam (FIB) tomography is a destructive technique used to collect three-dimensional (3D) structural information at a resolution of a few nanometers. For FIB tomography, a material sample is degraded by layer-wise milling. After each layer, the current surface is imaged by a scanning electron microscope (SEM), providing a consecutive series of cross-sections of the three-dimensional material sample. Especially for nanoporous materials, the reconstruction of the 3D microstructure of the material, from the information collected during FIB tomography, is impaired by the so-called shine-through effect. This effect prevents a unique mapping between voxel intensity values and material phase (e.g., solid or void). It often substantially reduces the accuracy of conventional methods for image segmentation. Here we demonstrate how machine learning can be used to tackle this problem. A bottleneck in

doing so is the availability of sufficient training data. To overcome this problem, we present a novel approach to generate synthetic training data in the form of FIB–SEM images generated by Monte Carlo simulations. Based on this approach, we compare the performance of different machine learning architectures for segmenting FIB tomography data of nanoporous materials. We demonstrate that two-dimensional (2D) convolutional neural network (CNN) architectures processing a group of adjacent slices as input data as well as 3D CNN perform best and can enhance the segmentation performance significantly.

Description

This dataset contains simulated FIB tomography data of nanoporous / hierarchical nanoporous gold, synthetic FIB-SEM images of hierarchical nanoporous gold and segmentation results of real hierarchical nanoporous gold dataset. For more information, please refer to published research article: Training deep neural networks to reconstruct nanoporous structures from FIB tomography data using synthetic training data

Folder structure

- `Root`
  - `Supplementary_Material.pdf` Supplementary material for manuscript.
  - `Paper_Data`
    - `Tables` All CSV files used to generate tables in manuscript.
    - `Figures` All Figures included in manuscript and suppl. material.
    - `Segmentation_Results` Segmented image files for hnpg/npg.
      - `hnpg_epoxy_TLD` Segmented files of hnpg_epoxy (TLD) using various methods
      - `hnpg_epoxy_ICD` Segmented files of hnpg_epoxy (ICD) using various methods
      - `npg_epoxy_TLD` Segmented files of npg_epoxy (TLD) using various methods
      - `npg_epoxy_ICD` Segmented files of npg_epoxy (ICD) using various methods
      - `Preprocessing` Segmented files of hnpg_epoxy using preprocessing
      - `synthetic_test_data` Segmented files of synthetic test data using various methods
    - `Simulated_Data` Simulated FIB tomography datasets of hnpg and their targets
    - `Anisotropy_Functions` Segmented files required to calculate TPCF/LPF.
      - `readme.txt` Description for anisotropy functions
      - `preprocess.ijm` Fiji macro file to preprocess segmented files