Contribution ID: **319**

Type: **Oral Presentation**

Determination of effective transport parameters on high-resolved 3D microstructures using CNN

Tuesday, 20 May 2025 11:50 (15 minutes)

The microstructure of (composite) materials is essential in assessing their performance in applications such as fuel cells, hydrogen storage and batteries. High-resolution microstructural data plays a critical role in optimizing the properties and functionalities of these materials. However, conventional imaging methods, such as CT scanning and FIB-SEM, are sometimes limited by their high expense and time required. To overcome these restrictions, we propose a deep learning-based approach to generate high-resolution from low-resolution 3D microstructure images. We present a SRResNet, a convolutional neural network (CNN) that is specifically trained on low-resolution microstructure data and provides a cost-effective and efficient approach for super-resolution reconstruction.

The SRResNet represents a significant progress in super-resolution technology by extending deep learning applications from 2D to 3D microstructures. To assess the physical properties and functional behaviour of the super-resolved 3D microstructures, we present a thorough morphological investigation. Effective transport parameters are a major focus of this study since they are essential for understanding and optimizing material performance. Key transport parameters such as effective tortuosity and permeability are computed using Laplace and Stokes equations, respectively, via finite element methods (FEM).

Our results show that the SRResNet captures intricate details of microstructural features with high fidelity reflected in metrics such as PSNR, SSIM, and surface accuracy. This work highlights the potential of SRResNet as a promising tool for material design and optimization, contributing to advancements in energy and transportation technologies

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References

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Session Classification: MS15

Track Classification: (MS15) Machine Learning and Big Data in Porous Media