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Application of Diffusion Models to Generate Multiphase Fluid Pore-Scale Images

Monday, 13 May 2024 17:00 (15 minutes)

Generative Adversarial Networks (GANs) have been a typical example of how machine learning has been successfully applied, using three-dimensional images as training datasets, to generate realizations of the pore space, as well as to produce super-resolution images. We further this work with a new generative model: diffusion models (DMs), to generate images of both the pore space and two fluid phases within the pore space, using experimental high-resolution three-dimensional X-ray images of the pore space and fluids at different fractional flows as training datasets. We demonstrate that using DMs, we can generate images for a range of saturations and compare the quality of these realizations against experimental data in terms of Minkowski functionals: saturation, interfacial area, mean curvature, and connectivity (Euler characteristic), as well as contact angle. DMs are a very promising algorithm type for the study of multiphase flow in porous media, with effectiveness comparable to, if not surpassing, GANs. We discuss the use of this methodology to complement pore-scale displacement and imaging experiments, to generate images of arbitrary size and for a wide saturation range. These images provide a basis for further analysis and pore-scale modeling, including the prediction of averaged multiphase flow properties, such as capillary pressure and relative permeability.

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References

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