Evaluation of Image Segmentation Methods Based on Synthesized Proxy Multiphase Porous Media

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Abstract

Recent technological advances in X-ray computed tomography (CT) provide increasingly powerful means for microporous media research with objectives ranging from theoretical aspects of pore scale fluid and interfacial dynamics to various practical applications such as oil and gas recovery, or remediation of dense nonaqueous phase liquid contamination. However, accurate segmentation of grayscale X-ray CT data to discern solid medium constituents and fluid phases remains a grand challenge. Because the exact phase (i.e., solid, liquid, and air) boundaries of an imaged porous medium are not known a priori, there is no reliable reference data for meaningful evaluation of porous media segmentation algorithms. To overcome this problem, we synthesized a three-phase porous medium proxy with exactly known phase boundaries by using a discrete element method in conjunction with lattice Boltzmann fluid dynamics simulations. This approach generates an artificial porous medium with known phase boundaries, comprising spherical particles along with liquid and air. Poisson noise was added, and the contrast and resolution of the synthesized media were varied to simulate image degradation experienced during X-ray CT data acquisition. The degraded data were then segmented with common segmentation algorithms to evaluate their susceptibility to various levels of image degradation. Segmentation results were then compared to the reference data.