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Image-based modeling of flow and reactive transport in porous media

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Due to the availability of powerful computational resources and high-resolution acquisition of material structures, image-based modeling has become an important tool in studying pore-scale flow and transport processes in porous media [Scheibe et al., 2015]. It is also playing an important role in the upscaling study for developing macroscale porous media models. Usually, the pore structure of a porous medium is directly discretized by the voxels obtained from visualization techniques (e.g. micro CT scanning), which can avoid the complex generation of computational mesh. However, this discretization may considerably overestimate the interfacial areas between solid walls and pore spaces. As a result, it could impact the numerical predictions of reactive transport and immiscible two-phase flow.

In this work, two types of image-based models are used to study single-phase flow and reactive transport in a porous medium of sintered glass beads. One model is from a well-established voxel-based simulation tool. The other is based on the mixed isogeometric finite cell method [Hoang et al., 2016], which has been implemented in the open source Nutils (http://www.nutils.org). The finite cell method can be used in combination with isogeometric analysis to enable the higher-order discretization of problems on complex volumetric domains. A particularly interesting application of this immersed simulation technique is image-based analysis, where the geometry is smoothly approximated by segmentation of a B-spline level set approximation of scan data [Verhoosel et al., 2015]. Through a number of case studies by the two models, we will show the advantages and disadvantages of each model in modeling single-phase flow and reactive transport in porous media. Particularly, we will highlight the importance of preserving high-resolution interfaces between solid walls and pore spaces in image-based modeling of porous media.

References

Hoang, T., C. V. Verhoosel, F. Auricchio, E. H. van Brummelen, and A. Reali (2016), Mixed Isogeometric Finite Cell Methods for the Stokes problem, Computer Methods in Applied Mechanics and Engineering, doi:10.1016/j.cma.2016.07.027.

Scheibe, T. D., W. A. Perkins, M. C. Richmond, M. I. McKinley, P. D. J. Romero-Gomez, M. Oostrom, T. W. Wietsma, J. A. Serkowski, and J. M. Zachara (2015), Pore-scale and multiscale numerical simulation of flow and transport in a laboratory-scale column, Water Resources Research, 51(2), 1023–1035, doi:10.1002/2014WR015959.

Verhoosel, C. V., G. J. van Zwieten, B. van Rietbergen, and R. de Borst (2015), Image-based goal-oriented adaptive isogeometric analysis with application to the micro-mechanical modeling of trabecular bone, Computer Methods in Applied Mechanics and Engineering, 284(February), 138–164, doi:10.1016/j.cma.2014.07.009.