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4D µCT reconstruction with improved time resolution for imaging fluid flow in porous media

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Computed micro-tomography (µCT) is a valuable tool to study transport phenomena in the 3D pore network of geomaterials. Recent advances, mainly at synchrotron beam lines but also using lab scanners, have made it possible to perform time-resolved µCT, imaging changes in the sample over time, with time resolutions on the order of seconds. In such cases, a 4D reconstruction is computed from a set of radiographs acquired during multiple rotations of the sample relative to the X-ray source and detector. Typically, a single 3D volume is computed to represent the time period associated with its set of radiographs, often inaccurately thought of as a single point in time, a time step. Therefore, during the acquisition of a single time step, dynamic changes in the sample (e.g. fluid occupancy) give rise to motion artifacts, which deteriorate the final image. A standard cone beam µCT reconstruction of a sample during capillary-dominated drainage (figure A) illustrates how sudden pore-scale fluid displacements disturb the results in the neighborhood of these pores. This may affect further analysis, e.g. the measurement of contact angles in two-phase flow experiments. To reduce these motion artefacts, it is key to keep the acquisition time as short as possible while still achieving a sufficiently high image quality.

To increase the time resolution of a typical µCT measurement several fold, the reconstruction approach presented here drastically limits the angular range of each time step. This shortens the considered time period, lessening the impact of motion artifacts. To compensate for the associated limited angle artefacts (illustrated in figure B), we propose to incorporate temporal total variation (TV) minimization into an iterative reconstruction technique (figure C). This temporal regularization effectively restores the spatial structure, while still resolving salient changes in the sample over time.

To validate the method, a synthetic dynamic 2D µCT dataset of a drainage experiment was created. Reconstructions were made with various angular window sizes (ranging from 12° to 200°), representing a *potential* increase of a factor 16.7 in the time resolution. The temporal attenuation curve of each pore was compared for the proposed technique and for a standard reconstruction. The improvements in time resolution of the µCT reconstructions with temporal TV minimization were quantified and found to be significantly improved. Application of the method to real measurement data suggests its suitability and usefulness towards imaging dynamic processes in porous materials.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

Berg, S., Ott, H., Klapp, S. a, Schwing, A., Neiteler, R., Brussee, N., et al. (2013). Real-time 3D imaging of Haines jumps in porous media flow. Proceedings of the National Academy of Sciences, 110(10), 3755–3759. https://doi.org/10.1073/pnas.1221373110

Bultreys, T., Boone, M. A., Boone, M. N., De Schryver, T., Masschaele, B., Van Hoorebeke, L., & Cnudde, V. (2016). Fast laboratory-based micro-computed tomography for pore-scale research: Illustrative experiments

and perspectives on the future. Advances in Water Resources, 95, 341–351. https://doi.org/10.1016/j.advwatres.2015.05.012

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