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Optimising Micro-CT Imaging Reconstruction Using Iterative Methods

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X-ray micro-CT is a non-invasive 3D imaging technique that allows the visualisation of the inner structure by obtaining 2D X-ray images at different angles. In recent years, micro-CT scanning has been extensively used for in-situ imaging of transport phenomena in porous media at the pore scale. However, the mentioned studies using lab-based micro-CT devices are generally limited to static imaging, given that the scanning times required for acquiring high-quality images are usually in the order of hours. While acquiring high-resolution images using a synchrotron beamline is in the order of seconds to minutes, which easily facilitates the in-situ imaging of dynamic processes, the access to these high flux sources is still limited in contrast with lab-based devices. Therefore, to approach dynamic in-situ imaging of flow processes with benchtop micro-CT scanning, reducing the image acquisition time of these devices with minimal loss of image quality is crucial. A practical approach to meet that end is decreasing the number of projections. Nonetheless, the conventional methods (analytical algorithms) to reconstruct 2D radiograms into 3D models need a large number of projections to provide high-quality images. In contrast, iterative reconstruction (IR) algorithms have been introduced to overcome the limitations of the analytical methods. IR methods have shown their capability in generating high-quality reconstructed images from under-sampled data. Despite that, since these algorithms use multiple repetitions to update the image until the best solution is found, their computational demand is much higher than that of analytical ones. Hence, finding the right balance between image quality and computation time and demands is of absolute necessity.
Accordingly, the objective of this work is to optimise micro-CT image quality and acquisition time by determining the suitable method of reconstruction and the sufficient number of projections. Here, we investigated two widely used IR methods, namely the simultaneous iterative reconstruction technique (SIRT) and the conjugate gradient least squares (CGLS) approach, in comparison with the most common analytical reconstruction method for cone-beam CT, the Feldkamp, Davis, and Kress (FDK) algorithm. We used the open-source ASTRA Toolbox on a micro-CT dataset acquired of a Doddington sandstone sample containing air and doped brine. We first reconstructed four different projection numbers of this dataset by using FDK, SIRT, and CGLS and then analysed the quality of the resulting images by calculating the signal-to-noise ratio (SNR) and quantifying the image sharpness. As the assessment of the analytical and iterative reconstruction algorithms based merely on pixel-based image quality determination methods may lead to an unfair comparison, we have also evaluated the discussed methods based on physical measures. For that purpose, we compared the segmented images of a number of selected reconstructions against a pre-set reference image. Our results indicated the clear advantage of CGLS compared to the other two algorithms in the optimisation of the number of projections required for reconstruction. CGLS showed to be capable of significantly reducing the acquisition time, down to a quarter of the original time, while providing significant improvement to the SNR and image sharpness, as compared to FDK.

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Participation

In person

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