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Digital Material Characterization Using the Quantum Fourier Transform

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Abstract : The efficient digital material characterization is of great interest to many fields of application. It consists of the following three steps. First, a 3D reconstruction of 2D scans must be performed. Then, the resulting gray-value image of the material sample is enhanced by image processing methods. Finally, partial differential equations (PDE) are solved on the segmented image, and by averaging the resulting solutions fields, effective properties like stiffness or conductivity can be computed. Due to the high resolution of current CT images, the latter is typically performed with matrix-free solvers. Among them, a solver that uses the explicit formula of the Green-Eshelby operator in Fourier space has been proposed by Moulinec and Suquet. Its algorithmic, most complex part is the Fast Fourier Transformation (FFT). In our talk, we will discuss the potential quantum advantage that can be obtained by replacing the FFT with the Quantum Fourier Transformation (QFT). We will especially show that the data transfer for noisy intermediate-scale quantum (NISQ) devices can be improved by using appropriate boundary conditions for the PDE, which also allows using semi-classical versions of the QFT. In the end, we will compare the results of the QFT-based algorithm for simple geometries with the results of the FFT-based homogenization method.

Keywords : most likelihood amplitude estimation (MLQAE), numerical homogenization, quantum Fourier transformation (QFT), NISQ devises
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