Adaptation and validation of FFT methods for homogenization of lattice based materials

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ABSTRACT

An FFT framework able to preserve the accuracy and good numerical performance in the case of domains with large regions of empty space is proposed and analyzed for its application to lattice based materials. Two FFT solvers able to resolve problems containing phases with zero stiffness are derived, a Galerkin approach [1] combined with MINRES linear solver and a discrete differentiation approach and a modification of a displacement FFT solver [2] which penalizes the indetermination of strains in the empty regions, leading to fully determined problem. The solvers are combined with several approaches to smooth out the lattice surface, based on modifying the actual stiffness of the voxels not fully embedded in the lattice or empty space. The accuracy of the resulting approaches is assessed for an octet-lattice by comparison with FEM solutions for different relative densities and discretization levels.

In this work, it is shown that the modified Galerkin approach combined with linear surface smoothening was the best FFT framework considering accuracy, numerical efficiency and best h-convergence. Respect numerical efficiency it was observed that FFT becomes competitive with FEM for cells with relative densities above 7%. Finally, to show the real potential of the approaches presented, the FFT frameworks are used to simulate the behavior of a printed lattice by using direct 3D tomographic data as input. The approaches proposed allowed to explicitly include in the simulation the actual surface roughness and internal porosity resulting of the fabrication process. The results show a large reduction of the lattice stiffness and was able to resolve stress localization of 50% near large pores.

REFERENCES
