Pixel Based Collocation Method for Multiscale Modeling of Microstructures

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The hierarchical biomaterials such as bones are heterogeneous in nature, particularly, with a porous composition. Consequently, the asymptotic homogenization was introduced to link the microscopic solid-fluid phase and the macroscopic balance laws. As high resolution digital imaging techniques emerge, the ability to reconstruct models and provide accurate predictions of material behavior becomes critical. Issues include the jagged boundaries, blurred objects, background noise, and mesh quality typically encountered in finite element modeling. The variational level set method is introduced for interface identification and boundary segmentation. Inspired by image pixels, a strong form collocation method, the gradient reproducing kernel collocation method (G-RKCM) is introduced to solve the level set equation and the microscopic cell problems, in which a determined discrete system requires only first order differentiation of approximation functions. A computational framework that can effectively model biomaterials is proposed and demonstrated to accurately perform a pixel based multiscale modeling of bone materials.

Keywords: image based modeling, gradient reproducing kernel collocation method, meshfree method, multiscale homogenization, porous media, bone mechanics