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Image Based Procedure for Bone Material Modeling

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For high resolution medical images, an image based procedure is developed in strong form to perform microstructure analysis. Consider heterogeneous biomaterials such as bone tissue with porous composition, the associated microscopic cell problems and homogenized mechanical properties have been derived through the asymptotic homogenization to correlate the hierarchy in the macro- and micro-scale. Nevertheless, for bio-images with highly irregular geometry, the process of model reconstruction by the traditional mesh-based methods unavoidably encounters issues such as mesh dependency and mesh distortion. Upon using the level set technique for model reconstruction, images of biological tissue showing complex topology can be identified and segmented into different phases effectively, such as the solid skeleton and pores in bone materials. In particular, the employment of the strong form collocation method takes advantage of point discretization and constitutes a seamlessly computational framework for solving level set equations and microscopic cell problems. In this work, a gradient reproducing kernel collocation method [3] is introduced for solving characteristic functions in the microstructures, in which only first derivatives of approximation functions are involved, thereby making the numerical scheme efficient for solving PDEs. The application to microstructure modeling of trabecular bone was demonstrated [1, 2]. The extension of the image based biomaterial modeling includes prediction of bone fracture, bone remodeling process, and design of bone-implant systems.

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