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ADAPTIVE ISOGEOMETRIC FAILURE ANALYSIS OF TRABECULAR BONE STRUCTURES

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Computational models play an important role in the calculation of reduced bone strength due to *e.g.* osteoporosis. Numerical simulations are required to adequately represent the microarchitecture of the bone in order to accurately identify bone strength. Microscale finite element techniques have been proposed that use a voxel conversion technique to represent the bone microstructure with brick elements. Although such analyses can predict bone stiffness, the inaccuracies in the representation of microscopic stresses prohibit their application to the computation of direct failure indicators.

In this work isogeometric analysis (IGA) [1, 2] is used to obtain a smooth representation of the bone microstructure. A volumetric analysis-suitable model is obtained by the application of the finite cell method [3]. A B-spline level set function is extracted from micro-CT scan data and is used to identify the computational domain. Some computational challenges associated with the finite cell method, such as the need for appropriate pre-conditioning of the system of equations, are studied.

Based on experimental observations on the various microscale failure processes in trabecular bone specimens, a gradient damage model is adopted in this study. This model introduces a length scale that makes the computational method objective with respect to the mesh size. Moreover, some physical characteristics of the system, such as *e.g.* a higher strength in compressive loading than in tensile loading, can be mimicked by this model. An advantage of isogeometric analysis compared to traditional finite elements is that higher-order gradients can be incorporated in the formulation, which provides enhanced stability and allows for the interpretation of the formulation as a non-local damage model [5].

To obtain an efficient computational method, mesh adaptivity is used to automatically refine the computational grid at places where damage accumulates. Hierarchical refinement [4] is used to locally refine the B-spline space to ensure sufficient analysis accuracy. The proposed method is elaborately tested in two dimensions, and preliminary three-dimensional results are discussed.

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