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AN EFFICIENT SOLVER FOR LARGE-SCALE SIMULATIONS OF VOXEL-BASED STRUCTURES USING A NONLINEAR DAMAGE MATERIAL MODEL

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In this talk we will present an efficient, scalable implementation of a nonlinear material model based on the existing high-performance linear voxel-based µFE solver ParOSol [1]. The material under consideration is bone, a highly hierarchical material consisting of structures on several different length scales. The trabecular structure is obtained from µCT imaging. This detail is necessary to capture the failure mechanism of bone on the trabecular level and to improve the prediction of bone strength.

The constitutive model features a failure mechanism based on a scalar damage quantity [2]. The stress state is found incrementally. In each increment, the stress prediction is obtained using the linear solver. The material is damaged if the local stress is too high. This procedure is applied iteratively.

µCT scans are input data for the automated mesh generator which is directly incorporated into ParOSol. Each voxel of the provided image is converted to a linear hexahedral element. A typical mesh for a radius segment (approx $4 \times 2 \times 0.6\,\mathrm{cm}^3$) has about 200 mio elements with a resolution of $16.4\,\mu\mathrm{m}$.

First performance evaluations show promising results. The linear solver is known to be highly scalable on thousands of processors. Future investigations will be conducted to show an equally good scaling for the nonlinear extension.

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