Simulating fracture of real wood microstructures using a phase field finite element method

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ABSTRACT

Like most biological materials, wood is a complex material – it is built up from molecules of e.g. cellulose which form composite cellulose nano-fibrils which in turn form composite fibres which in a complex manner make up the tree trunk. Therefor it is usually necessary to limit oneself to one or a few length scales and/or fracture planes. In this study we focus on the – in numerical studies – not so common cell scale.

We propose a finite element model for fracture of wood, endowed with a phase field model for fracture, that takes the actual microstructure of the wood into account. The phase field method for fracture has been shown to accurately predict quasi-static and dynamic fracture and crack paths in materials containing pores [1]. Based on imaging of real wood microstructures, we predict crack paths and compare the prediction to reported (experimental) results from the literature. The fracture mode under consideration is (macroscopic) mode I. Two load cases dominate in the experimental literature on mode I fracture of wood, the compact tension (CT) specimen, and the micro-wedge splitting specimen. While similar, the former is a pure mode I load case, for which displacements in the singularity dominated zone can be determined analytically to reduce the size of the computational model [2].

In spite of the lack of lower-order length scale behaviour, the model produces remarkably similar crack paths compared to experiments, cf. [3]. This suggests that it is possible to simulate also more complex load cases, including cutting and grinding, with the aim to control e.g. fiber defibration processes in pulping industry or properties for grinding materials.

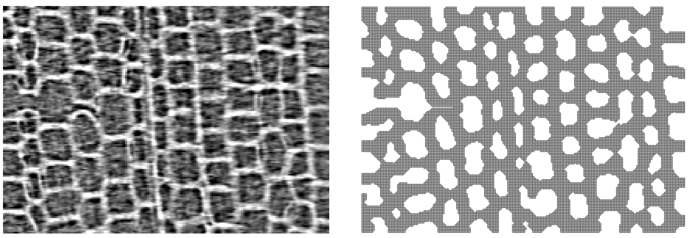

Figure 1: Discretisation of an image. Left: Original image from μCT imaging. Right: Computational grid.

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