Using Convolutional Neural Networks for Enhanced X-ray µComputed Tomography Wood Images Segmentation

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Interactions between wood and water is a major concern when it comes to wood and wood-based materials. Changes in the moisture content of these products cause dimensional instabilities and swelling forces in the wood cell walls that can affect their properties and performance. However, the underlying causes for the moisture-induced swelling of wood at the cell wall level are not completely understood.

In this study, we used X-ray µ-Computed Tomography (XµCT) to image the internal structure of wood slivers to quantify dimensional volumetric changes when exposed to relative humidity changes. Fast scanning phase-contrast XµCT experiments were performed using a custom-built humidity chamber. XµCT scans were taken at four relative humidity conditions: 0%, 30%, 75% and 95%. The specimens were equilibrated for 24 hours at each relative humidity before the scanning.

A modified version of the U-Net convolutional neural network was used for image segmentation. For the training process, we used 78 ground-truth images. The number of training images was increased by randomly partitioning the ground-truth images into 588 x 588-pixel sub-images and employing data augmentation. After the data augmentation, the number of images was increased to 14,010. Seventy percent of the images were assigned for training, while the remaining images were used for model validation. The network was trained using a stochastic gradient descent algorithm for a total of 30 epochs.

The cell wall moisture-induced volumetric dimensional changes will be reported. Furthermore, the values of the wood cell wall hygroscopic expansion coefficients will be presented. These values are a material property that could be used to model and predict the moisture-induced swelling of wood cell walls. Our findings would lead to a better understanding of the moisture-induced swelling of wood cell walls.