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Application of deep learning segmentation techniques in smartphone images to assess growth of fine roots of spruce seedlings manipulated by air humidity and soil nitrogen source

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A new insight in root growth dynamics is presented in this study, where pictures of root growth were taken with personal mobile phones and analysed by the machine learning based program RootPainter (Smith et al. 2020). Todays' smartphones provide high-quality photos and user-friendly free software enables rapid processing of these images. We aimed to explore 1) how accurate the results are of the deep learning segmentation models created for assessing root growth, 2) how the changes in relative air humidity and dominating soil nitrogen source and their interactions influence root growth.

Picea abies trees were grown separately in transparent boxes in growth chambers in moderate or elevated air humidity and on nitrate or ammonium soil source. The pictures of roots were made from each side of boxes every week, together six sessions. The pictures were analysed with RootPainter twice, one where total root projection area was measured, second with only young white roots.

The total root growth was highest in trees growing in moderate air humidity and on ammonium source, lowest in elevated air humidity grown on nitrate source, 9.4 ± 1.9 and 3.9 ± 0.6 cm2, respectively. The young root projection area was highest in the beginning of experiment, and was affected by the soil nitrogen source. The amount of lignified roots increased over time and was affected by the air humidity treatment. The F measure was 0.88, when we compared a subset of automatically measured pictures to manually annotated pictures. We will further discuss about the magnitude of the errors 1) where the program identified "root as soil" and "soil as root", and 2) where the root projection area of young roots was greater than the total root projection area. We did not discover treatment-specific bias in our error measurements. We conclude that the combination of smartphone images and RootPainter gives accurate and reliable results and is easy to use in plant growth manipulation experiments in the future.

Smith AG, Han E, Petersen J, Olsen NAF, Giese C, Athmann M, Dresbøll DB, Thorup-Kristensen K. 2020. RootPainter: Deep learning segmentation of biological images with corrective annotation. bioRxiv, doi:10.1101/2020.04.16.044461