Root phenotyping research: Automated total root length estimation from in situ images without segmentation

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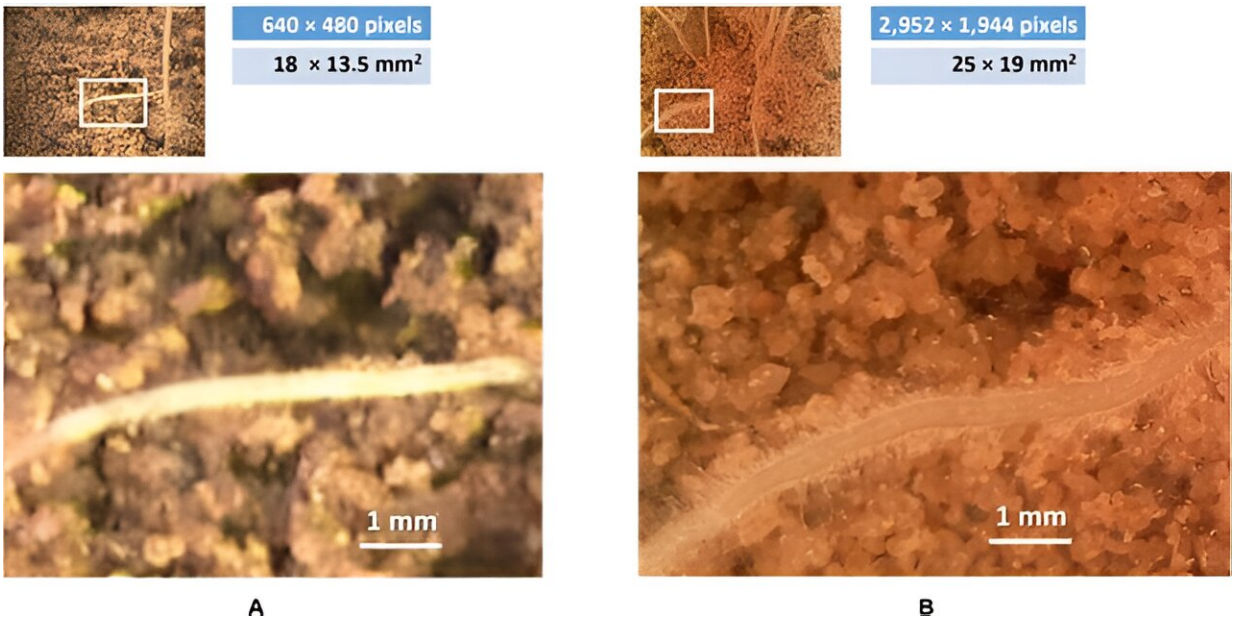

Comparison of root images taken using (A) a conventional manual MR system or (B) an automated MR system. Credit: *Plant Phenomics* (2023). DOI: 10.34133/plantphenomics.0132

Climate change stresses severely limit crop yields, with root traits

playing a vital role in stress tolerance, thus highlighting the importance of root phenotyping for crop improvement. Recent advances in image-based root phenotyping, particularly through the minirhizotron (MR) technique, offer insights into root dynamics under stress. However, the manual and subjective nature of MR image analysis poses significant challenges.

This highlights the need for automated imaging systems and tools to streamline and objectify the process, enhancing the efficiency and objectivity of root phenotyping.

In January 2024, *Plant Phenomics* published a research article titled "Automatic Root Length Estimation from Images Acquired In Situ without Segmentation." This study advances the field of root phenotyping by adapting convolutional neural network-based models for estimating total root length (TRL) from MR images without the need for segmentation.

Utilizing manual annotations from Rootfly software, researchers explored a regression-based model and a detection-based model that identifies annotated root points, with the latter offering a visual inspection capability of MR images.

The models were rigorously tested across 4,015 images from diverse crop species under varied abiotic stresses, demonstrating high accuracy (R^2 values between 0.929 and 0.986) in TRL estimation compared to manual measurements. This accuracy underscores the potential of our approach to significantly enhance root phenotyping's efficiency and reliability.

The study's results indicate that the detection-based model generally

outperforms the regression model, particularly in challenging datasets, by incorporating additional root coordinate information. This finding is critical for high-quality image datasets, where automated TRL estimation remains robust.

Moreover, researchers conducted a sensitivity analysis to highlight the impact of image quality and dataset size on model performance, revealing the significant influence of image quality. The models' ability to differentiate between images with and without roots, with a minimal error margin, further illustrates their practical utility in precision agriculture by enabling real-time monitoring of root growth.

The analysis was then extended to evaluate root length density (RLD) calculations, demonstrating the models' effectiveness in capturing root distribution patterns in soil, which is vital for understanding water and nutrient extraction. The models' capability to track root dynamics over timeâ€"including the identification of root disappearanceâ€"highlights their potential to inform timely agricultural decisions regarding water and nutrient management.

In conclusion, this research presents a groundbreaking approach to root phenotyping, offering robust, automated tools for TRL estimation from MR images, thereby facilitating the rapid and accurate assessment of root growth patterns. This advancement holds significant promise for enhancing precision agriculture practices, enabling growers to make informed decisions based on detailed root growth information.

More information: Faina Khoroshevsky et al, Automatic Root Length Estimation from Images Acquired In Situ without Segmentation, *Plant Phenomics* (2023). DOI: 10.34133/plantphenomics.0132

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