A new method for expanding in situ root datasets using CycleGAN

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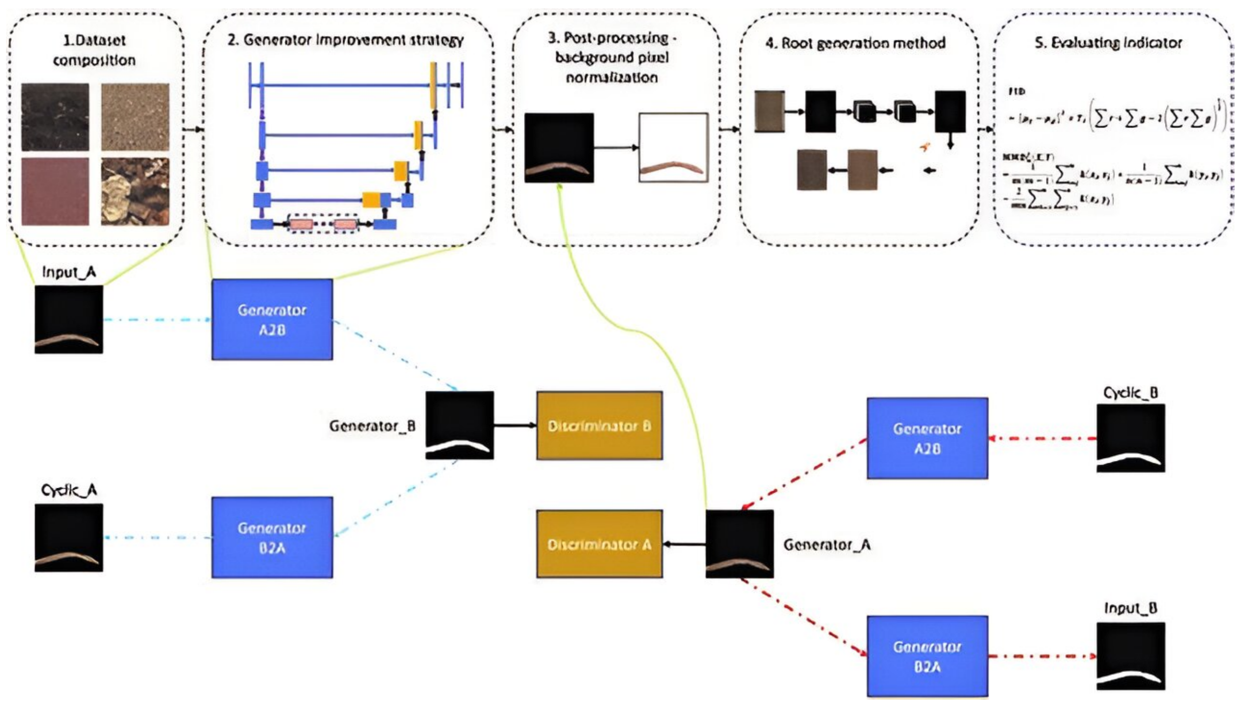

Experimental pipeline. Credit: *Plant Phenomics* (2024). DOI: 10.34133/plantphenomics.0148

The root system is crucial for plants to absorb water and nutrients, with in situ root research providing insights into root phenotypes and dynamics. While deep-learning-based root segmentation methods have advanced the analysis of root systems, they require extensive manually labeled datasets, which are labor-intensive and time-consuming to produce. Current methods of in situ root observation vary in their effectiveness.

Moreover, traditional root image recognition methods face challenges such as subjectivity and low efficiency, whereas deep learning approaches offer improved accuracy but are hindered by the need for large, annotated datasets. Addressing the dataset limitation through innovative methods like CycleGAN for dataset generation presents a potential solution, yet challenges remain in ensuring the diversity and accuracy of the generated images for effective training and analysis in root segmentation studies.

Plant Phenomics published research titled "In Situ Root Dataset Expansion Strategy Based on an Improved CycleGAN Generator."

This research introduces a novel method for augmenting in situ root datasets through an improved CycleGAN generator coupled with a spatial-coordinate-based method for target background separation, addressing the challenge of background pixel variation. By leveraging this approach, the study demonstrates significant enhancements in speed, accuracy, and stability over traditional threshold segmentation methods.

The method also facilitates the inclusion of diverse culture mediums in root images, boosting dataset versatility. Experimental results, utilizing an RTX 3060 12 GB + 16 GB platform for training, show that the application of an Improved_UNet network to the augmented dataset yields a modest yet notable improvement in mean intersection over union (mIOU), F1 score, and accuracy, indicating the method's efficacy in improving dataset quality and generalization across different root system architectures.

Specifically, the improved dataset contributed to a 0.63% increase in mIOU, 0.41% in F1 score, and 0.04% in accuracy, with generalization performance seeing even more significant increases. The research method involved detailed CycleGAN training with specific parameters and subsequent validation through comparative and subjective evaluations, including the input of various generator structures and postprocessing techniques.

In conclusion, the findings underscore the potential of the proposed dataset augmentation strategy to enhance the analysis of root systems, with future work aiming to achieve more realistic simulations through advanced shading and soil type variability. This expansion strategy, validated by the Improved_UNet network's performance on the augmented dataset, marks a promising advancement in root system analysis, offering a scalable solution to the limitations of existing root image datasets.

More information: Qiushi Yu et al, In Situ Root Dataset Expansion Strategy Based on an Improved CycleGAN Generator, *Plant Phenomics* (2024). DOI: 10.34133/plantphenomics.0148

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