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Convolutional neural network-based automatic root length measurement in noisy rhizosphere images

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The use of minirhizotron (MR) imaging systems is gaining popularity, resulting in a large amount of collected images—which need efficient and accurate processing for root trait extraction. This study proposes a neural network-based solution for automatic measurement of root length in images taken by MR systems. Current root length measurement techniques involve two steps; manually operating the MR for taking the images, and manually annotating roots in front of a noisy rhizosphere 'background' with a dedicated software. As the analysing process is extremely time consuming, automation can both lower the costs and facilitate greater temporal resolution.

Using convolutional neural networks (CNN) in image classification tasks has become very common due to its simplicity, yet regression tasks are still considered difficult. We propose a new model that combines the strength of conditional learning, transfer learning and bagging in order to achieve a precise regression. The dataset used holds 12,000 highly diverse images of 5 tomatoes cultivars, which were collected by a BARTZ minirhizotron camera over a period of 4 months.

Initial results show a success rate of 75% accuracy with 33 mm Mean Absolute Error (MAE). Error analysis shows that large errors occur on images with either a very high or a low root length density. Additionally, a separate model was designed and tested on selected subsets of the data by using a synthetic data generator. Results show that MAE decreases to 10 mm, which is equivalent to 90% accuracy.

Results suggest that this method has great potential to facilitate fully automatic root length measurement on noisy rhizosphere images. Future work will validate the proposed model with a larger datasets comprising of various plant species, soil types and MR imaging systems.