High-frequency *in situ* root phenotyping achieved by automated Minirhizotron image acquisition and analysis

Zhou Kaining[1], Kaining Zhou[2], Adam Soffer[3], Jhonathan E. Ephrath[2], Ofer Hadar[3], and Naftali Lazarovitch[2]

[1]Affiliation not available
[2]French Associates Institute for Agriculture and Biotechnology of Drylands, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer, Israel
[3]School of Electrical and Computer Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel

December 14, 2022

Abstract

Minirhizotron technique (MR), an image-based root phenotyping technology, has expanded our understanding of in situ root responses to changing environmental conditions. However, the conventional manual approaches to capturing and analyzing images are time-consuming, thus constraining the size and frequency of sampling and interpretation. To address this bottleneck, an automated MR system was developed, which worked in a fully automatic manner according to the pre-set schedule. Users can remotely control the system and download images. This system was tested in a net house by imaging bell pepper roots on a daily basis, which shows superior performance over commercial manual MR systems in terms of image resolution and sampling frequency. Besides, an image analysis model was built on convolutional neural networks to estimate root length from MR images directly without segmentation in the training process. This model was trained on a dataset of ˜18,000 tomato root images taken by a manual MR camera and was used for estimating root length on 832 bell pepper root images taken by the automated MR camera. The high correlation coefficient ($R^2 = 0.854$) between the model estimation and manual measurement proved that this model generalizes well over different crop roots and camera types. Therefore, high-frequency in situ root phenotyping can be achieved by the automated Minirhizotron image acquisition and analysis tools proposed here.

NAPPN Annual Conference Abstract:

High-frequency *in situ* root phenotyping achieved by automated Minirhizotron image acquisition and analysis

***Kaining Zhou*[1]**, *Adam Soffer*[2], *Jhonathan E. Ephrath*[1], *Ofer Hadar*[2], *Naftali Lazarovitch*[1]

[1]*French Associates Institute for Agriculture and Biotechnology of Drylands, Jacob Blaustein Institutes for Desert Research, Ben-Gurion University of the Negev, Sede Boqer Campus, Israel*

[2]*School of Electrical and Computer Engineering, Ben-Gurion University of the Negev, Beer Sheva, Israel*

ORCiD: 0000-0002-9259-6854

Keywords: Root phenotyping, Minirhizotron technique, image analysis, convolutional neural network, root length estimation, Automation,

Minirhizotron technique (MR), an image-based root phenotyping technology, has expanded our understanding of *in situ* root responses to changing environmental conditions. However, the conventional manual approaches to capturing and analyzing images are time-consuming, thus constraining the size and frequency of sampling and interpretation. To address this bottleneck, an automated MR system was developed, which worked in a fully automatic manner according to the pre-set schedule. Users can remotely control the system and download images. This system was tested in a net house by imaging bell pepper roots on a daily basis, which shows superior performance over commercial manual MR systems in terms of image resolution and sampling frequency. Besides, an image analysis model was built on convolutional neural networks to estimate root length from MR images directly without segmentation in the training process. This model was trained on a dataset of ~18,000 tomato root images taken by a manual MR camera and was used for estimating root length on 832 bell pepper root images taken by the automated MR camera. The high correlation coefficient (R^2 = 0.854) between the model estimation and manual measurement proved that this model generalizes well over different crop roots and camera types. Therefore, high-frequency *in situ* root phenotyping can be achieved by the automated Minirhizotron image acquisition and analysis tools proposed here.