Non-Destructive Monitoring of Underground Root Development with Deep Learning-Based ResNet and In-Soil Fiber Optic Sensors

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Non-destructive, real-time monitoring of root development can be helpful to farmers in improving crop resilience while minimizing resource use (Mervin et al., 2022). However, it is still an unexplored frontier in understanding root responses efficiently. In this study, we employed three in-soil fiber Bragg grating (FBG) based fiber sensors to generate root phenotyping data and developed an automated method using the deep learning architecture ResNet to monitor underground root development. In our preliminary study, we conducted a simulation experiment using two metal rods with diameters of 1mm and 5mm to mimic plant's roots. These rods were inserted to a depth of 15 cm in two different scenarios, 6 and 11 minutes, with the three in-soil FBG sensors continuously collecting data—two FBGs placed on the sides, and one placed at the bottom. The sensor data was preprocessed, resulting in 3228 samples for root diameter and 477 for root depth prediction models. We used an 80/20 split for training and testing the ResNet models to predict the artificial root diameter and ten different depth levels. The achieved accuracy was 0.95 for depth and 0.91 for diameter prediction. Overall, our study demonstrates the potential of ResNet architectures to accurately predict root depth and diameter with fiber optics-based sensors. Therefore, non-destructive root phenotyping in agricultural applications might be possible. Future work will involve evaluating these models in field experiments to assess their real-world performance.

References:

Mervin Chun-Yi Ang, Tedrick Thomas Salim Lew (2022). Non-destructive Technologies for Plant Health Diagnosis, Front. Plant Sci., 27 May 2022, Sec. Technical Advances in Plant Science, Volume 13.