3D Root Structure Modeling and Analysis Using Close-Range Photo Scanning

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Abstract

This work presents a methodology for creating digital twins of root system architecture (RSA) that can be used for studying the phenotypic variation in RSA. Growing populations demand increased global food production. To sustainably support this increase, crops must be developed to flourish in nutrient-depleted soils. Since the effectiveness of nutrient uptake is determined by plant rooting system dynamics, much focus has been placed on studying RSA across species and varieties. A particularly effective tool for studying RSA in 3D has been X-ray computer tomography (CT). However, this technology is cost prohibitive and cannot model field-grown samples. A far more cost-effective technology is close-range photogrammetric scanning, which uses multiple 2D images to reconstruct 3D point clouds of RSA. This project develops a point cloud processing pipeline that takes high-density point clouds of soybean rooting structures and generates 3D RSA models. These digital twins are then used as the basis for analyzing the phenotypic variation of the geometric and biometric features of the RSA. We believe this digital twin construction and analysis pipeline will increase the impact of RSA research in support of sustainable food production in nutrient-depleted areas of the world.

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