Enhancing Multi-View 3D Reconstruction of Plant Roots using Super-Resolution and 3D Gaussian Splatting

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Abstract

Quantifying 3D phenotypic traits for plant shoots and roots is essential to monitor and evaluate plant growth and development. Multi-view stereo (MVS) is a low-cost and widely used photogrammetry method to build 3D point clouds in many agricultural applications. However, it is challenging to adopt MVS directly to obtain complete 3D structures of fine roots for plants such as soybeans. To address this problem, we propose a data processing pipeline incorporating super-resolution (SR) and 3D Gaussian Splatting (GS) to enhance the resolution of 3D root reconstruction, aiming to recover a highly detailed 3D root structure. To this end, first, multi-view images of a soybean root are collected using an RGB camera; second, SR is used to optimize the resolution of the images; third, the processed images are fed to the algorithm structure from motion to obtain a point cloud; and then, 3D GS is applied to enhance the implicit 3D surface reconstruction; finally, perceptual similarity and peak signal-to-noise ratio (PSNR) are used to evaluate the output quality. The method is expected to obtain a high-fidelity 3D reconstruction of plant roots for soybeans and other crops, assisting in the extraction of comprehensive phenotypic traits to accelerate the selection of new varieties for plant breeding.

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