ABSTRACT
Structural reconstruction of plant roots from MRI is challenging, because of low resolution and low signal-to-noise ratio of the 3D measurements which may lead to disconnectivities and wrongly connected roots. We propose a two-stage approach for this task. The first stage is based on semantic root vs. soil segmentation and finds lowest-cost paths from any root voxel to the shoot. The second stage takes the largest fully connected component generated in the first stage and uses 3D skeletonization to extract a graph structure. We evaluate our method on 22 MRI scans and compare to human expert reconstructions.

BRANCH EXTRACTION

F1 SCORE FOR GRAPHS
► Generate dense point representation for manual and algorithmic extraction
► If points are close enough spatially and branch orientation matches, they correlate
► Using correlating points Precision and Recall are computed

DATASET
► 22 Plant root MRI scans with human expert extraction
► Segmented by 5 different 3D U-Net models
► LOG1 loss and root weighting 1, 10, 100, 1000 were employed

RESULTS DEPENDING ON INPUT AND PARAMETERS
► Performance was tested with respect to three algorithm parameters
► Models retaining correct surface perform best
► Models with low root weight loss to much structure
► Models with high root weight retain more noise and create merging structures

QUALITATIVE ASSESEMENT
► Branches get extracted by unique connections
► Root like structures not found in manual extraction were extracted
► Merging volumes lead to merged extraction

DISCUSSION
► We proposed a fast, robust pipeline to extract root graphs from 3D MRI scans
► Large datasets can be computed fast on modest hardware
► Possible root structures not part of the manual reconstruction were found
► Two areas to be improved were found:
  ► Merging root structure can result in merging extraction
  ► Shortest path gap closing can be inaccurate
  ► A dynamic model based on root growth could reduce both
  ► An iterative approach for extraction can be tried
► Use algorithm output as basis for manual improvements

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