CT-tomography for individual projects

The calculation is provided for 6 different scenarios and refers to one object, e.g. **one** soil column or subsample.

Scenarios

(1) Scan of a whole soil column according to SCE (20 cm height, 7 cm ∅), segmentation of pore system and quantification of pore size distribution, pore connectivity, total porosity (for the given resolution) and distance map based on pores of a certain size. – two scans covering 15 cm of column height

(2) Scan of a whole soil column according to SCE (20 cm height, 7 cm ∅), segmentation of root system and quantification of root volume and root length, distance map based on root system.

(3) Combination of (1) and (2)

(4) Scan of subsample from SCE or from undisturbed soil cores from the SPE (field), in analogy to (1) (i.e. pore oriented)

(5) Scan of subsample from SCE or from undisturbed soil cores from the SPE (field), in analogy to (2) (i.e. root oriented)

(6) Scan of subsample from SCE or from undisturbed soil cores from the SPE (field), in analogy to (3) (i.e. root and pore oriented).

Prior to submitting the proposals, PI's need to discuss with the coordinator of the SPP aims and expectations related to CT scanning. The person months calculated for individual proposals based on net-work time listed in the tables will be included in the coordination project and funded therein, in case the respective individual project gets funded.

In preparation for any scanning, i.e. prior to the setup of the experiment the experimenter needs to discuss his aims, and expectations related to CT scanning with the coordinator of the PP or the person assisting the coordinator. The experimenter needs to have participated in the respective tutorial of the PP which points out the potential pitfalls; in particular artefacts created by poor packing of soil columns have to be avoided, if roots shall be detected. Specific requirements of timing need to be discussed and special requirements of minimizing X-ray dose and potential trade-offs need to be clarified.

Further annotations

Voxel size depends on the size of the object, i.e. for 10 cm ∅ voxel side length is 60 µm, for 7 cm ∅ 40 µm, for 5 cm 30 µm, for 3 cm 18 µm and for 1 cm 6 µm. Maize roots can only be detected properly for objects ≤ 7 cm ∅.

For objects with height larger than diameter (scenario (1) to (3)), two scans have to be performed and data need to be stitched before further processing. Hence size of the files increase and thus, for many steps processing time increases as well.

File size of raw image for 16 bit reconstruction is 10 GB; for 8 bit reconstruction 5 GB; twice the size for stitched images; i.e. 20 and 10 GB respectively.

Filament needs to be renewed on average after 70 h of scan-time, this requires 8 h.

Each new set of objects requires **parameter optimization** before scripts can be run automatically. For this, another **12 h of net-work time** have to be taken into account.

The steps listed below produce as a delivery 3D pictures of the root system, pore structure or distance map. Including quantitative measures for the whole object like porosity (based on the given resolution), pore connectivity, pore size distribution, root volume, and the basis for calculation of root length. The respective file formats are listed below.

A one week tutorial will be provided as during the first phase of the PP addressing the CT work, issues of data handling and image registration. Based on past experience, however, this is often not sufficient for the data being actually used by the experimenter (mostly the PhD student). In addition, a joint evaluation of the data will be conducted; i.e. visualize further details of interest, calculate measures for subunits, calculate further measures, help in registering data from different sources. This process needs to be a joint one, i.e. the experimenter needs to be present in Halle and from our side the respective time has to be calculated. We recommend at least 20 h net-working time. Further joint analyses can be agreed upon based on joint data publication.

Data storage

Raw image and segmented 3D pictures will be stored on the UFZ data sever in mirrored form as backup. Experimenters are expected to bring along portable hard drive for receiving their copy. Storage capacity needs to be appropriate, i.e. one raw image ranges between 5 and 20 GB (see above).

Detailed description of work flow for different scenarios

(1) Whole column; pore oriented

Step	Type of work	File format	Net-work time
1	2 scans including handling of sample, start-up of process	raw/tif	3.00 h
2	Stitching of adjacent raw images	raw/tif	0.25 h
3	Cropping of the raw picture	raw/tif	0.25 h
4	Denoising of the image	raw/tif	2.00 h
5	Segmentation of pore space	raw/tif	2.00 h
6	Calculation of pore size distribution, porosity, pore connectivity, Distance map based on pores	raw/tif	1.50 h
7	Proportionate maintenance work (filament)		0.25 h
	Σ		9.25 h

(2) Whole column; root oriented

Step	Type of work	File format	Net-work time
1	2 scans including handling of sample, start-up of process	raw/tif	3.00 h
2	Stitching of adjacent raw images	raw/tif	0.25 h
3	Cropping of the raw picture	raw/tif	0.25 h
4	Denoising of the image	raw/tif	2.00 h
5	Shape detection of tubular roots	raw/tif	1.00 h
6	Segmentation for roots	raw/tif	2.00 h
7	Distance map based on roots + statistics	raw/tif txt/csv	0.50 h
8	Derive root skeleton from segmented roots for root length determination*	txt/csv	5.00 h
9	Proportionate maintenance work (filament)		0.25 h
	Σ		14.25 h

(3) Whole column; pore and root oriented

Step	Type of work	File format	Net-work time
1	2 scans including handling of sample, start-up of process	raw/tif	3.00 h
2	Stitching of adjacent raw images	raw/tif	0.25 h
3	Cropping of the raw picture	raw/tif	0.25 h
4	Denoising of the image	raw/tif	2.00 h
5	Shape detection of tubular roots	raw/tif	1.00 h
6	Segmentation for roots	raw/tif	2.00 h
7	Segmentation for pores	raw/tif	2.00 h
8	Calculation of pore size distribution, porosity, pore connectivity, Distance map based on pores	raw/tif txt/csv	1.50 h
9	Distance map based on roots + statistics	raw/tif txt/csv	0.50 h
10	Derive root skeleton from segmented roots for root length determination*	txt/csv	5.00 h
11	Proportionate maintenance work (filament)		0.25 h
	Σ		17.75 h

(4) Subsample; pore oriented

Step	Type of work	File format	Net-work time
1	1 scan including handling of sample, start-up of process	raw/tif	1.50 h
2	Cropping of the raw picture	raw/tif	0.25 h
4	Denoising of the image	raw/tif	1.00 h
5	Segmentation for pores	raw/tif	1.00 h
6	Calculation of pore size distribution, porosity, pore connectivity, Distance map based on pores	raw/tif txt/csv	1.00 h
7	Proportionate maintenance work (filament)		0.25 h
	Σ		5.00 h

(5) Subsample; root oriented

Step	Type of work	File format	Net-work time
1	1 scan including handling of sample, start-up of process	raw/tif	1.50 h
3	Cropping of the raw picture	raw/tif	0.25 h
4	Denoising of the image	raw/tif	1.00 h
5	Shape detection of tubular roots	raw/tif	0.50 h
6	Segmentation for roots	raw/tif	1.00 h
7	Distance map based on roots + statistics	raw/tif	0.25 h
8	Derive root skeleton from segmented roots for root length determination*	txt/csv	2.50 h
9	Proportionate maintenance work (filament)		0.25 h
	Σ		6.25 h

(6) Subsample; pore and root oriented

Step	Type of work	File format	Net-work time
1	1 scan including handling of sample, start-up of process	raw/tif	1.50 h
3	Cropping of the raw picture	raw/tif	0.25 h
4	Denoising of the image	raw/tif	1.00 h
5	Shape detection of tubular roots	raw/tif	0.50 h
6	Segmentation for roots	raw/tif	1.00 h
7	Segmentation for pores	raw/tif	1.00 h
8	Calculation of pore size distribution, porosity, pore connectivity, Distance map based on pores	raw/tif txt/csv	1.00 h
9	Distance map based on roots + statistics	raw/tif txt/csv	0.25 h
10	Derive root skeleton from segmented roots for root length determination	txt/csv	2.50 h
11	Proportionate maintenance work (filament)		0.25 h
	Σ		9.25 h

Example for calculation of required person months:

Scanning of 12 soil columns (20 cm height, 7 cm diameter), one point in time, corresponding to two treatments with six replications at final harvest, pore oriented (1) only.

(12 x 9.25 h) + 12 h + 20 h = 143 h net-work time.

Net-work time per month:

Based on the year 2017 the net-work time per month is calculated as follows:

260 week days (Monday to Friday) – 10 public holidays - 30 vacation days = 220 working days per year, corresponding to 1760 working hours per year; i.e. **147 net-working hours per month**.

Hence 143 h net-work time corresponds to 0.97 person months;

Brought up to a round figure → 1 person month postdoctoral researcher or comparable level (E13, Level 3 to E14 Level 2) according to DFG personnel rates in 2021 → 6.300,- Euro.