X-RAY COMPUTED TOMOGRAPHY FOR STATE OF THE ART PLANT AND ROOT ANALYSIS

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ABSTRACT

During the last years, the formerly in medical applications established technique of X-ray computed tomography (CT) is used for non-destructive material analysis as well. Adapting this technique for the visualization and analysis of growth processes of plants above and underneath the soil enables new possibilities in the so called smart agriculture. Using State-of-the-art CT systems the computed 3D volume datasets allows the visualization and virtual analysis of hidden structures like roots or tubers in the substrate, or a detailed structural analysis of sprout features like caulis, leaves and branches. This is a completely renewed approach to phenotyping without the need of a huge amount of plants. Due to the non-destructive technique time resolved CT measurements can be conducted at the same plant.

CT is based on the generation of multiple X-ray projections of the specimen from different angles of view. The projection dataset is used for computing a three-dimensional CT volume dataset whereas the spatial resolution depends on geometrical properties of the CT system and the reconstruction algorithm. As a special application for this kind of CT experiment the in-situ measurement of the growth of potatoes tubers will be presented with a strong emphasis on the evaluation of the 3D volume data. This is of special interest due to the predicted climate change in the next years. Hot periods in early growth stages are critical for some varieties of potatoes. Different applications for phenotyping evaluation will be discussed additionally.

In contrast to most of the established techniques for tuber analysis the plant growth is not affected by CT directly. Depending on the application and the geometric access special CT acquisition and image evaluation methods had to be developed and used. A high quality 3D measurement requires a 3D access to the object as well. An outlook of developments in X-ray components, imaging and volume data set analysis methods, possible system setups, applications and possibilities will conclude the poster.

POSTER SUMMARY

Using X-ray imaging or Computed Tomography (CT) enables the possibility to access hidden structures in a non-destructive way. Thus, the volume gain or even the three-dimensional ordering of roots or tubers below the surface can be measured without unearthing the plant itself. In Fig 1, a typical setup is sketched for CT measurements.

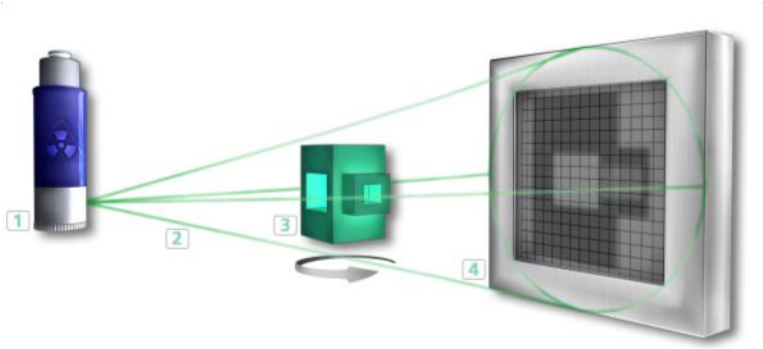

Fig. 1. Schematic drawing of a typical CT-Setup. The X-ray tube (1) emits a cone beam (2). The sample (3) is positioned at a rotation stage and the flat panel detector (4) records one projection for each angular step.

A two-dimensional projection is recorded at each angular step. After the measurement this dataset of projections is used to reconstruct the 3D volume. Therefore, the quality of the reconstructed volume is dependent on the amount of recorded 2D projections and the algorithm used for the reconstruction.

As illustrated in Fig. 2 not only roots and tubers can be measured, it is also possible to visualize the inner part of a walnut. The main advantage for using CT in phenotyping is the possibility to evaluate the structure in a non-destructive way in 3D or 2D. Thus, it is possible to track the individual growth of potato tubers, nuts, roots, grains, leaves and branches.

The main task is to adapt the parameters of the CT system to the special problem. This is of importance because intrinsically there is only a small absorption contrast between the different biological materials.

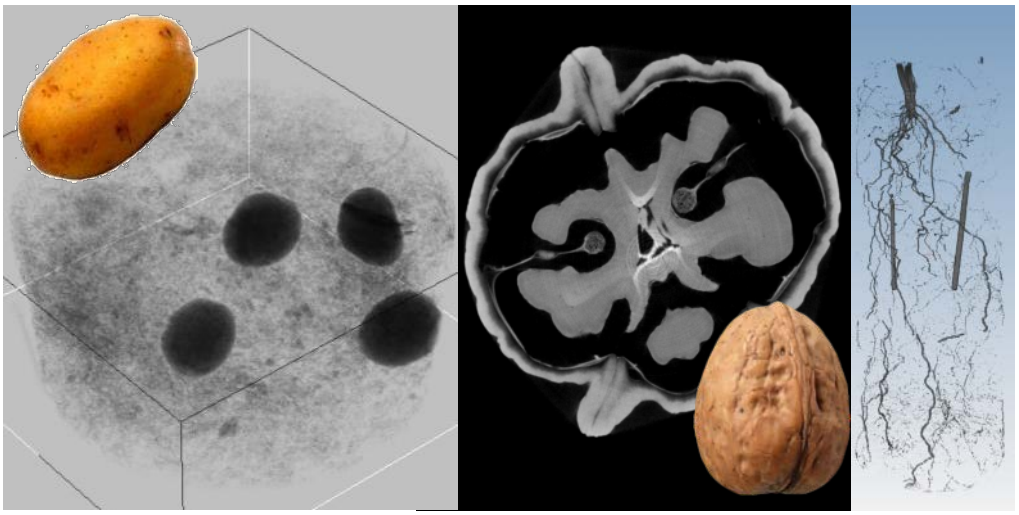

Fig. 2. Visualization of different applications for CT phenotyping. First, a 3D visualization of a plant pot with potatoes inside, second a virtual cut through a walnut and third, the three-dimensional structure of roots in the soil (from left to right).

Keywords: Computed tomography, non-destructive phenotyping, in-situ tuber analysis