RHIZOSPHERE SPATIOTEMPORAL ORGANISATION

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An improved method for the segmentation of roots from X-Ray computed tomography 3D images : Rootine v.2

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Introduction & motivation

X-ray computed tomography (CT) is a powerful tool for the study of root system architecture (RSA) of plants grown in opaque soil (Fig. 1). The study of RSA is however only possible after performing root segmentation, i.e. the binarization of all root and background voxels. The objectives of this work are to develop a segmentation algorithm for which :

1. the parameters are related to root properties (i.e. the root grey value and diameter);
2. the number of parameters involved is reduced;
3. the root recovery rate is higher;
4. the segmented root diameters are better captured.

The ability of the new algorithm to fulfill these criteria will be evaluated by comparison with the former algorithm Rootine (here referred to as "Rootine v.1") on the benchmark dataset of the so called "worst case" scenario described in Gao et al. (2019).

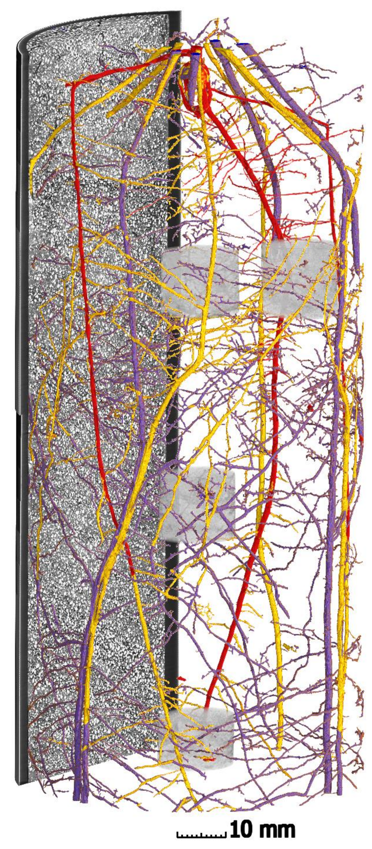

Fig. 1 shows possible RSA studies by CT image analysis after performing root segmentation and registration of images obtained after 7, 14 and 21 days after sowing (DAS) of a *Zea mays* plant.

7 DAS

14 DAS

21 DAS

Fig. 1 *Example of RSA study performed via CT images analysis.*

Methodology

Two keysteps were added to the Rootine v.1 workflow (Fig. 3). The first one allows to enhance the contrast between the roots and the back ground whereas the second performs an automatic calculations of the sigma values to be used during the Gaussian smoothing with "Tubeness filter". The latter was established by analyzing the grey value transect of a root of a diameter d_r filtered with a sigma value σ (Fig. 2). We introduce a parameter q in order to normalize the results (i.e. $q = \sigma/d_r$, expressed in number of voxels). Setting q =0.5, retrieving the corresponding grey value (i.e. red dot on Fig. 2) and taking the scaling factor (f_s) into account, we derive :

$$\sigma_i = d_{r,i} * f_s * 0.5$$

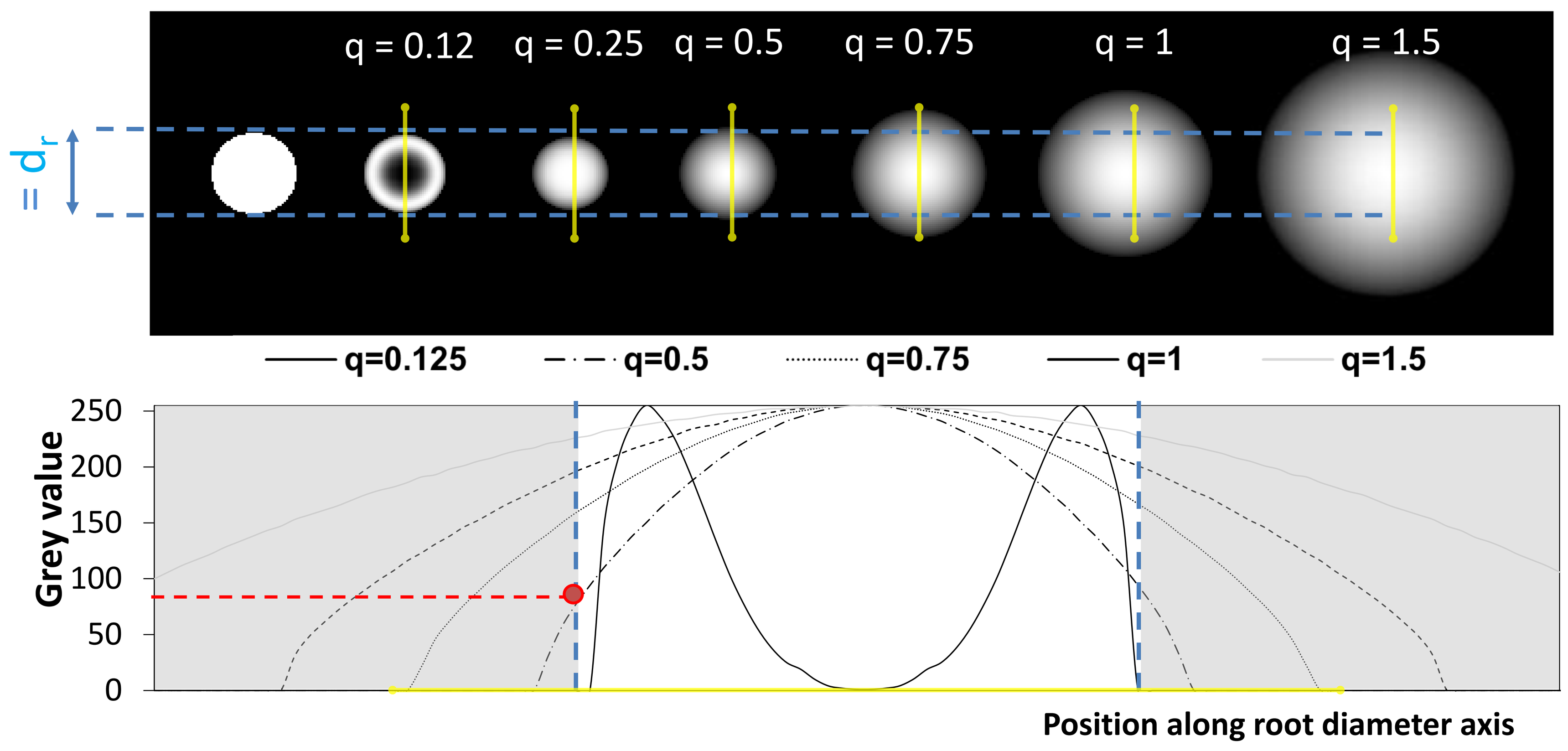

Fig. 2 *Automatic calculations of the sigma values to be used during Gaussian smoothing*

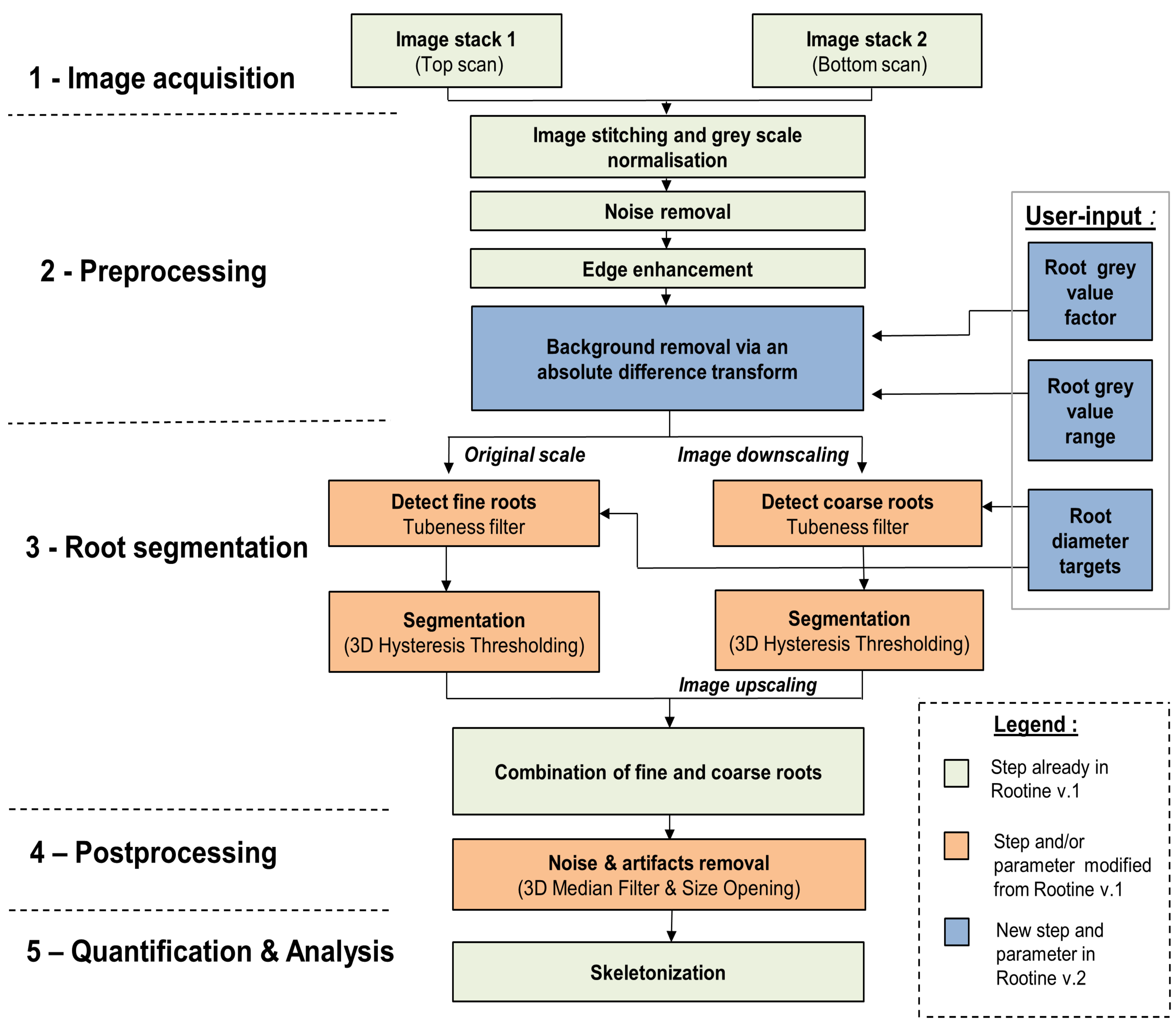

Fig. 3 *Synoptic view of the Rootine v.2 algorithm*

Results

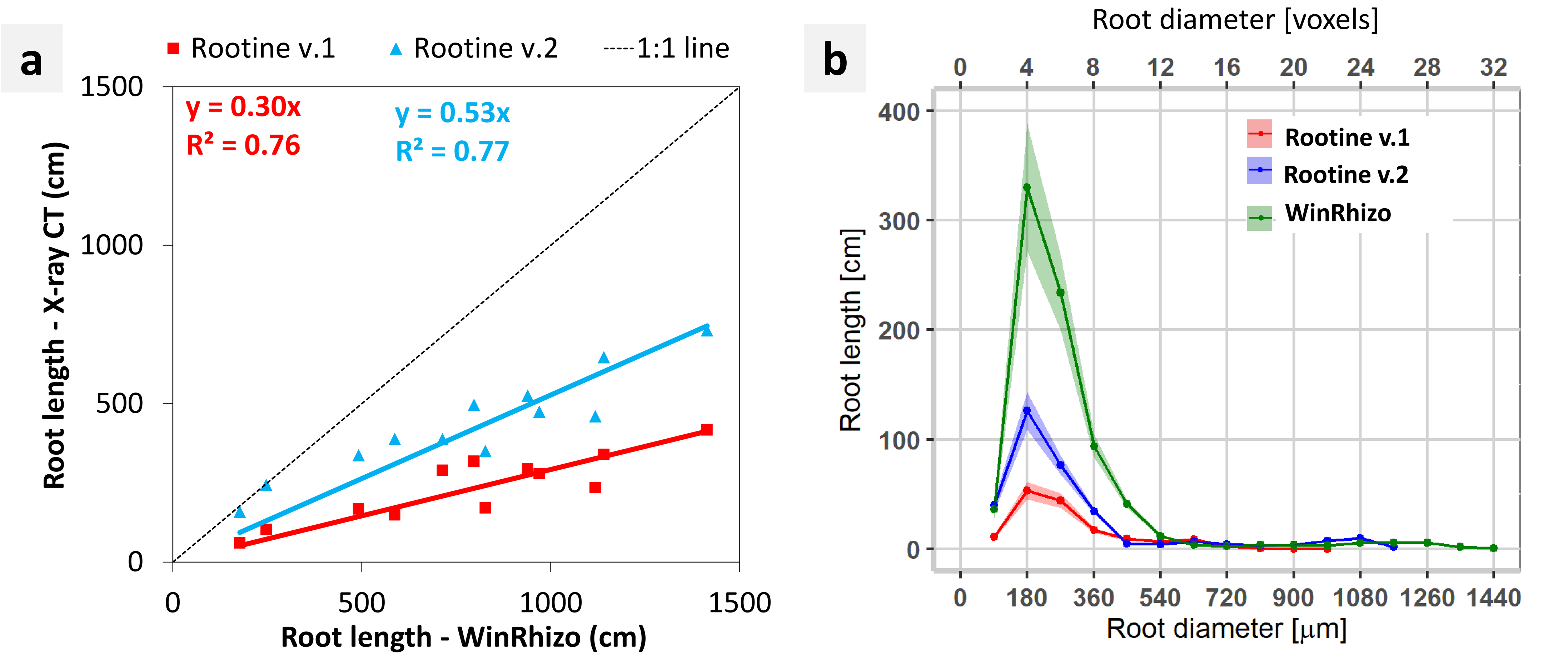

Fig. 4 *Root recovery rate (a) and diameter evaluation (b) of Rootine v.2 as compared to v.1 and WinRhizo data*

Discussions and conclusions

On the "worse case" benchmark dataset of Gao et al. (2019), Rootine v.2 …

1. Performed **better** than Rootine v.1 in terms of **root recovery** (Fig. 4a) **and diameter evaluation** (Fig. 4b);
2. Involves **less parameters** to be calibrated by the user thanks to the addition of formalising steps (**7 vs. 13 in Rootine v.1**);
3. Involves **parameters** which are are **directly related to root properties.** This facilitates the interpretation of parameters and their effects for non-expert users.

Gefördert durch

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References :

1 - Gao, Wei, et al. "A shape-based method for automatic and rapid segmentation of roots in soil from X-ray computed tomography images: Rootine." *Plant and Soil* (2019): 1-13.

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