Reeb graph based examination of root development

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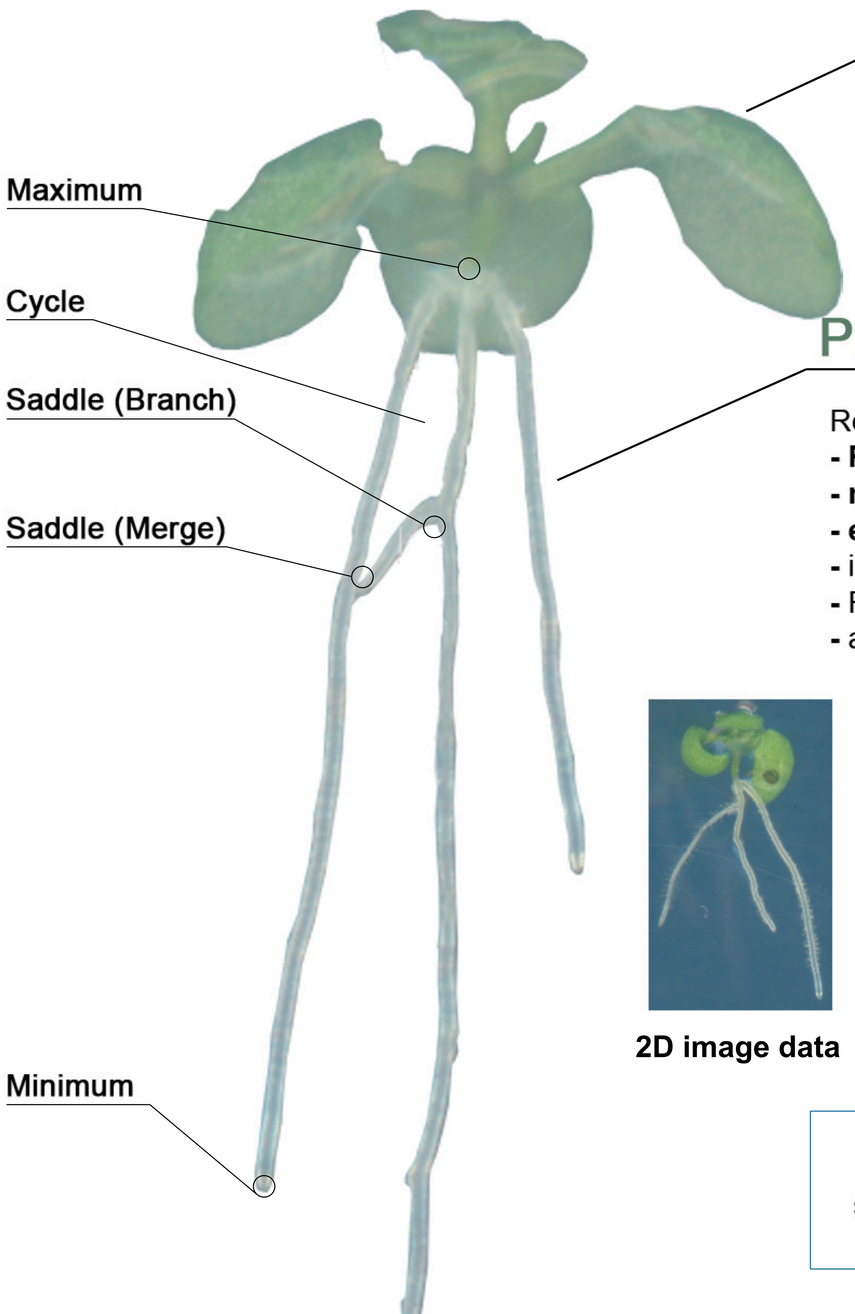


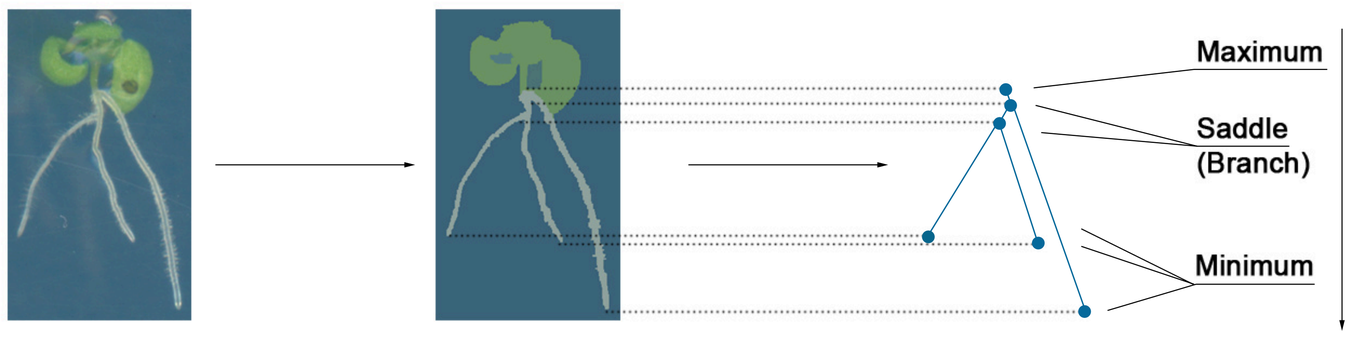
Introduction to phenotyping

phenotype (Greek: *phainein* = to show) - composition of an organism's observable characteristics

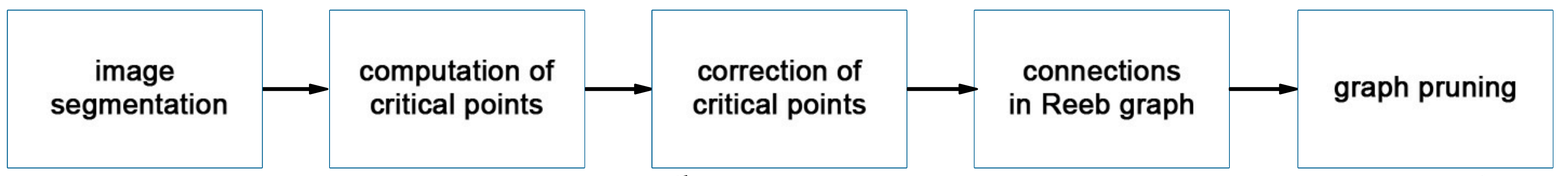
phenotyping of the plant ***Arabidopsis thaliana***:
- **characteristics** of the root such as **branching points** and **branch endings** are analyzed
- these characteristics can be **efficiently described** by a skeletal **graph** representation

Presented method

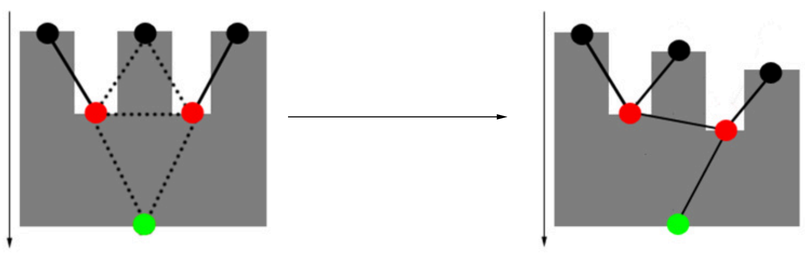
Root characteristics described by **Reeb graphs** (according to **height function**):
- **Reeb graphs preserve topological information**
- **nodes** in Reeb graphs correspond to **critical points** (points of change in topology)
- **edges** in Reeb graphs describe **topological persistence** [1]
- in **2D critical points** (nodes in the Reeb graph) are **minima, maxima or saddles** [2]
- Reeb graphs are **based on Morse theory** but have been extended to the discrete domain
- according to Morse theory: for all pairs of **distinct critical points x_1 and x_2**, $f(x_1) \neq f(x_2)$ **holds**[2]



2D image data → **segmented image** → **Reeb graph representation**



critical points on same height



move integer coordinates of point $p = (x, y)$

to $p' = (x, y + f)$
with $f = \frac{1}{w} \cdot (x - 1)$ and w = image width

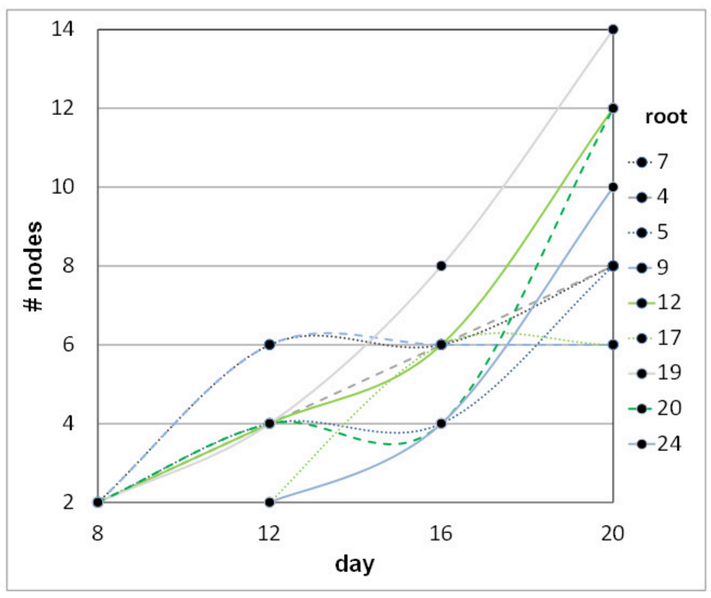
graph pruning

to reduce number of spurious nodes in the Reeb graph

frayed borders = artefacts
due to segmentation
results in additional branches in graph

Results

numbers of nodes in the 34 root images:

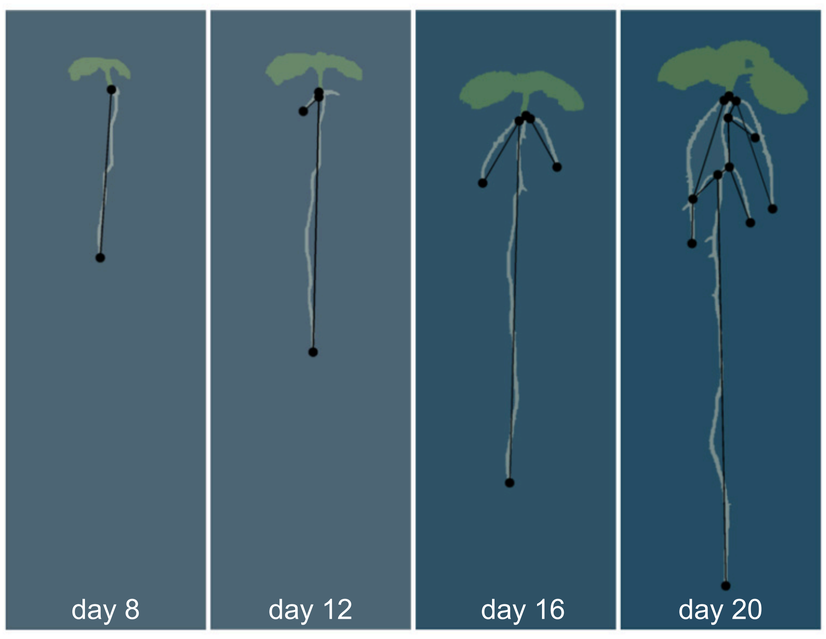


cycles in the 34 root images:

	1 cycle in root
day 16	7, 19
day 20	4, 5, 7, 12, 20
	2 cycles in root
day 20	19

$$\#edges = (\#nodes - 1) + \#cycles$$

root 12



Conclusion and future work

Reeb graphs:
- suitable descriptors for root structures
- capture the main characteristics of roots well: branches and branch endings
- branching points and overlaps in 3D can be immediately distinguished (cycle in Reeb graph)

Future work:
- different segmentation approach (larger dataset)
- various functions used to build the Reeb graph

References

[1] S. Biasotti, D. Giorgi, M. Spagnuolo, and B. Falcidieno. Reeb graphs for shape analysis and applications. Theoretical Computer Science, 392(13):5–22, Feb. 2008.
[2] Harish Doraiswamy and Vijay Natarajan. Efficient algorithms for computing Reeb graphs. Computational Geometry, 42(67):606–616, Aug. 2009.

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