Computer visualisation of root morphogenesis

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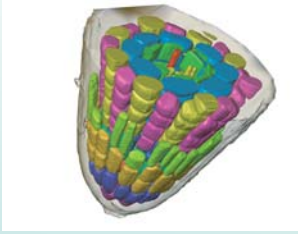
Background

- The dynamics of cell growth and expansion in roots underlies root function and morphogenesis.
- This new project aims to develop tools to visualise these processes in Arabidopsis roots by analysing confocal microscope images.
- Techniques will be adapted from computer vision & statistical modelling, geotechnical engineering, root biophysics, and molecular and cell biology.
- A computational framework will be developed for interfacing with future developments and studies in cell biology.

Organisation of cells in the Arabidopsis root



Cells in the Arabidopsis root meristem (Escience1 project, J. Haseloff)

Longitudinal section through an Arabidopsis root showing developmental zones superimposed on an epidermal cell layer (Escience1 project, J. Haseloff; image by E. Truernit)

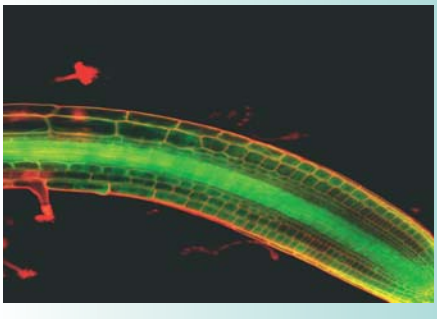
Project plan

- Improve and automate methods for cell segmentation from stacked confocal images
- Extract spatio-temporal data from stacked confocal images by tracking cell location, shape, and size as a function of time (i.e. in 4-D).
- Visualise cell expansion in 4-D using dual-labelling and fluorescent cell reporters.
- Develop models to run visual simulations of root growth.

Techniques to be applied

Confocal microscopy

- Will be used to capture time-lapse optical sections through living roots.

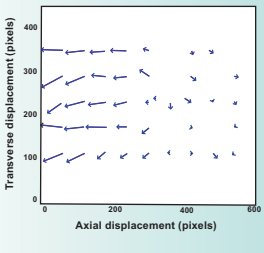


Dual fluorescent labelling of cell walls (red) and microtubules (green) in an Arabidopsis root.

Microtubules may partly regulate the direction of cell expansion, by controlling the orientation of cellulose microfibril deposition in cell walls.

P article image velocimetry

- Will be used to measure local velocity fields between successive timelapse images.

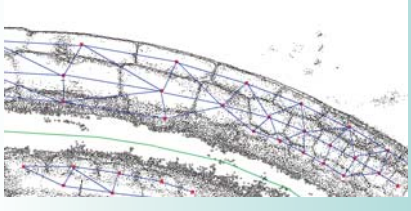


Particle image velocimetry will be used to track the displacement of patches of pixels between successive timelapse images.

The figure shows some preliminary data on the velocity field within the cells of an Arabidopsis root.

Elastic-graph matching

- Will be used to track trajectories of segmented cells as a function of time.



An impression of how cells will be tracked is given above.

The central axis of the root is indicated by the green line, cell centroids by red nodes, and the presence of shared cell boundary segments by blue lines.

Acknowledgements

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