AVATARS
3D Modeling of Growing Seeds

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AVATARS – THE CONSORTIUM

Goals

Generation of statistical shape models and analysis of tissue growth in different lines of *B. napus* using 3D MRI images of different seeds from different developmental stages.

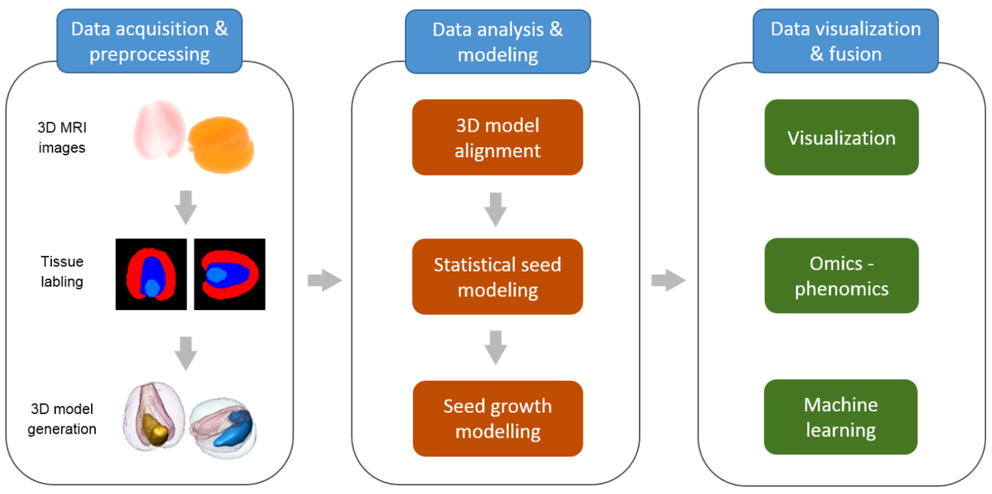
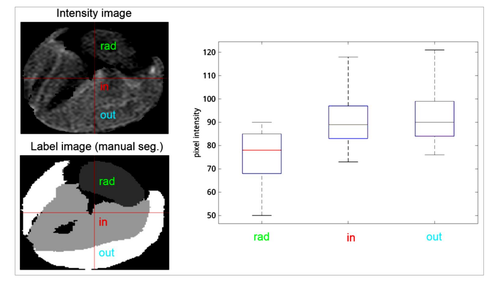
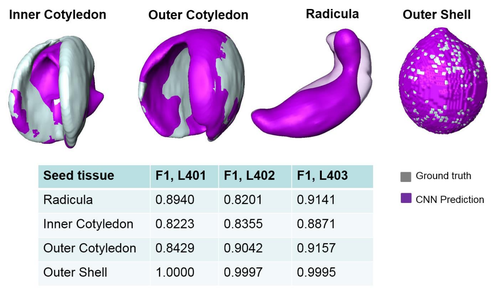


Image segmentation

MRI intensities of different seed tissues exhibit a relatively low contrast which hampers a straightforward image segmentation.





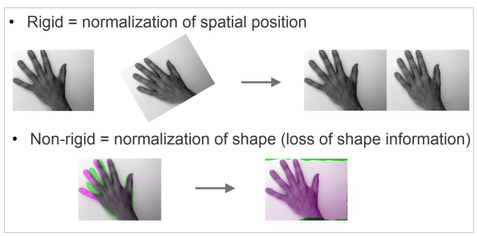
Seed tissue	F1, L401	F1, L402	F1, L403
Radicula	0.8940	0.8201	0.9141
Inner Cotyledon	0.8223	0.8355	0.8871
Outer Cotyledon	0.8429	0.9042	0.9157
Outer Shell	1.0000	0.9997	0.9995

Deep learning segmentation model trained on totally 60 3D MRI images shows a lower accuracy for inner seed tissues (radicula, cotyledons).

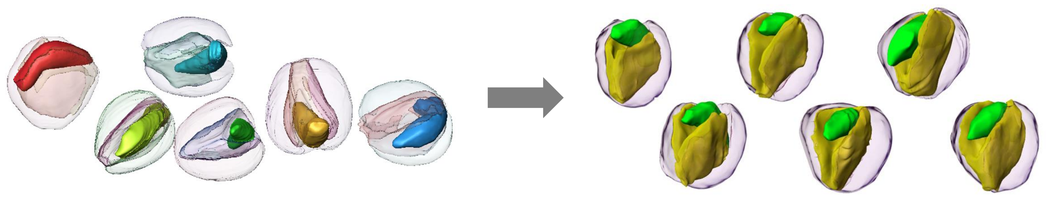
Consequently, manual or semi-automated segmentation is required for accurate reconstruction of 3D seed structures.

Seed image registration

Rigid registration such as translation, rotation preserves the shape, while non-rigid registration (warping) destroys shape information.



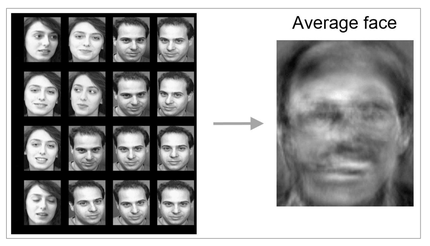
Co-registration of five seed models



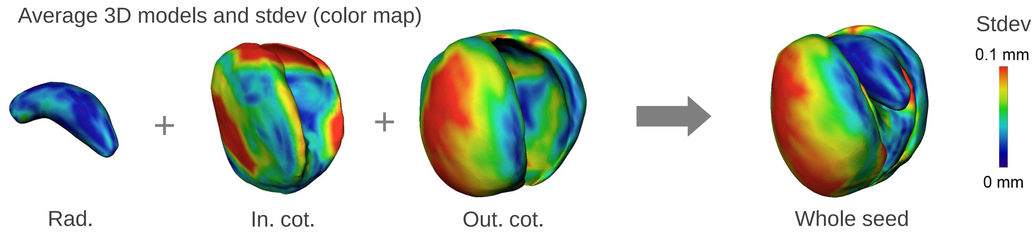
Consequently, rigid registration is applied for alignment of 3D images and models of five different seeds from each developmental stage.

Seed vs. tissue modeling

Statistical modeling of complex biological structures as a whole (e.g., whole face, whole seed), can be associated with topological inconsistencies.



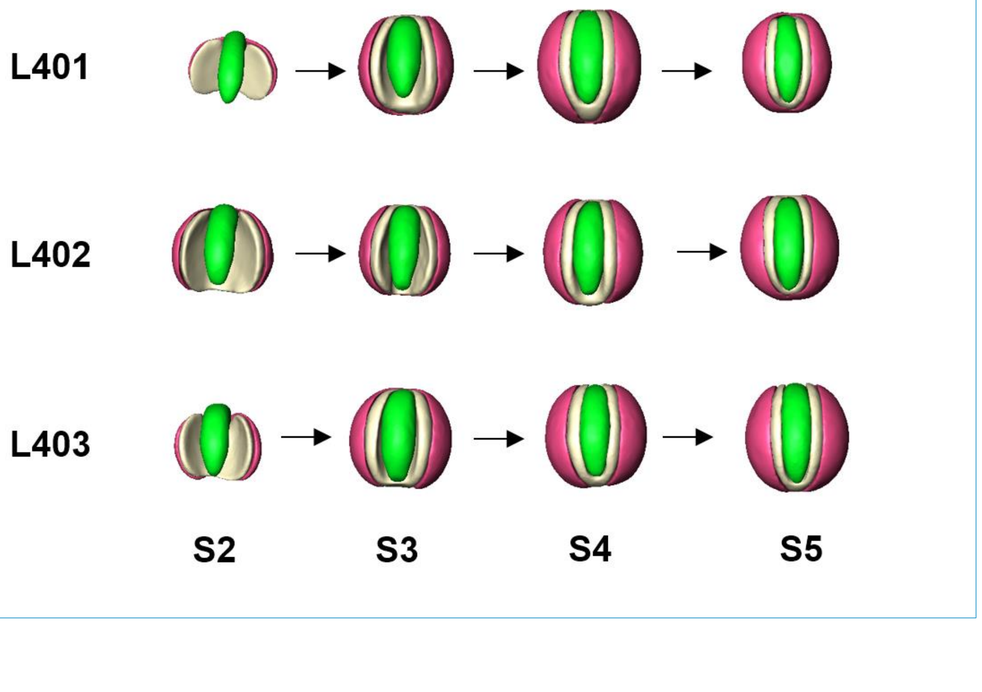
Average 3D models and stdev (color map)



Consequently, 3D image alignment as well as statistical shape modeling were performed for each seed tissue separately. Statistical models of different seed tissues were then merged to a single 3D model of the whole seed.

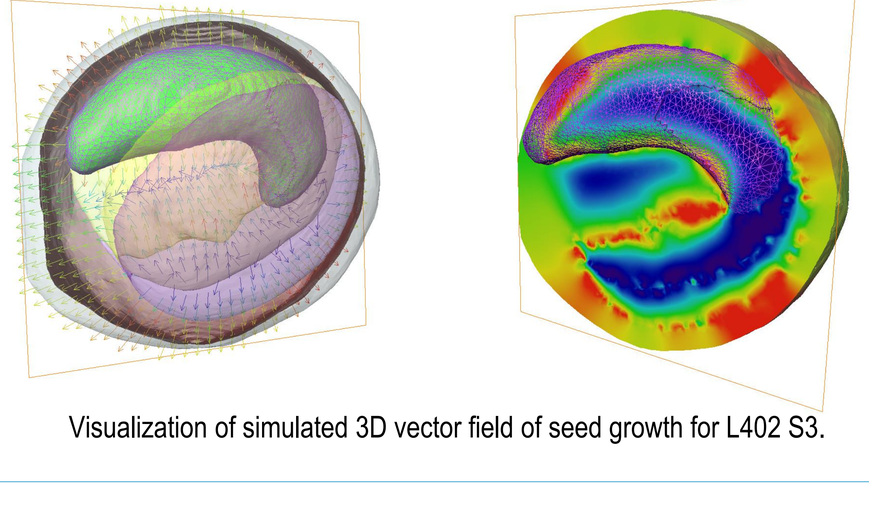
Statistical shape modeling

Based on registered, normalized 3D models of five seeds per each condition, statistical 3D shape models of three different seed lines and four subsequent developmental stages of *B. napus* were generated.



Simulation of seed growth

Conventional image analysis allows assessment of simple traits of biological structures such as volume, area, shape. To explore mechanical properties of growing seeds, computational simulation is required. In the first feasibility study, a simulation of 3D mechanical seed response to anisotropic pressure on tissue boundaries was performed.



Visualization of simulated 3D vector field of seed growth for L402 S3.

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