

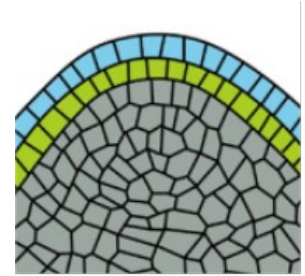
Master's / Engineer Internship Proposal

Automated Segmentation and Classification of Cellular Structures

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Host team: MOSAIC Inria Project Team
(MORphogenesis Simulation and Analysis In siliCo)
www.ens-lyon.fr/RDP/morphogenesis-simulation-and-analysis-in-silico-mosaic

Host lab: Reproduction et Développement des Plantes (RDP),
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Aim and background: Different cellular structures often coexist in imaging data both from material and biological specimens. One example of such type of image is the cross-section of a plant tissue, where we find a layered cell structure close to the surface, and more isotropic, random arrangement in the bulk region. Differentiating these classes in any cellular material is critical for quantifying structural properties, diagnosing states and eventually guide fabrication or treatment decisions. The aim of the internship is to develop an automated image-analysis pipeline to segment and classify these cellular structures.

Existing segmentation methods typically focus on identifying and tracking either individual cells (1) or entire organs at the tissue level (2). However, the intermediate scale — where both a cell and its immediate neighborhood are considered — remains underexplored. In our team, a Python package has been developed and is widely used to implement cell segmentation and lineage tracking algorithms (3). The tool developed during this internship will establish a correspondence between multiscale mechanical models of growing plant tissues (4) and experimental data.

Proposed tasks: (i) Define specific features that characterizes and allows to discriminate the two cellular structures (geometrical parameters, anisotropy index,...), (ii) Build a segmentation framework that classifies regions according to the two types of cell structures, (iii) Provide explainable diagnostics (metrics on characteristic features that show why the model classified a cell and its neighborhood in a certain way), (iv) Release code, annotated dataset, and user-facing scripts for the community.

Required skills: We seek motivated students with a background in physics, applied mathematics and good programming skills in Python. Strong interest in interdisciplinary research combining biology, physics, and mathematics is also essential.

References:

- (1) R. Fernandez, P. Das, V. Mirabet, E. Moscardi, J. Traas, J.L. Verdeil, G. Malandain, C. Godin, Imaging plant growth in 4D: robust tissue reconstruction and lineaging at cell resolution, *Nature Methods*, 2010
- (2) A. Kiss, T. Moreau, V. Mirabet, C.I. Calugaru, A. Boudaoud, P. Das, Segmentation of 3D images of plant tissues at multiple scales using the level set method, *Plant Methods*, 2017
- (3) TimageTK (Tissue Image ToolKit) <https://mosaic.gitlabpages.inria.fr/timagetk/index.html>
- (4) A. Boudaoud, A. Kiss, M. Ptashnyk, Multiscale Modeling and Analysis of Growth of Plant Tissues, *SIAM Journal on Applied Mathematics*, 2023

