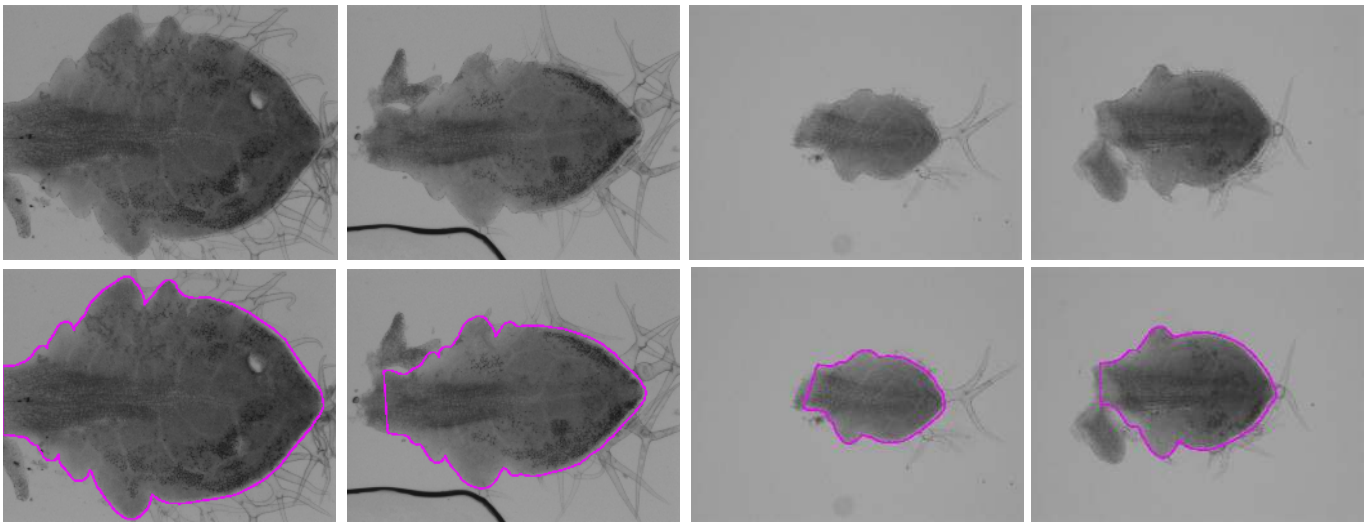
6-month internship: Deep Learning for 2D leaf microscopy image segmentation

Subject presentation

This project addresses a broader question related to understanding the biological mechanisms involved in organ morphogenesis, i.e. the process by which organs shape themselves during growth. Our study model is the rosette leaf of the model plant Arabidopsis thaliana. For technical reasons, it is not possible to follow a single leaf throughout its entire growth. Our strategy is to make use of collections of 2D images obtained by microscopy of leaves taken from different plants at different developmental stages, with the aim of reconstructing an average growth trajectory (Biot et al., 2016; Oughou et al., 2023). In this context, it is essential to segment the contours of each digitised leaf. However, this is a challenging task (see examples below, raw image and segmented contour). The strategy currently used is based on the classic “watershed” method, which requires a significant amount of manual correction. This work is tedious and very time consuming, as typically dozens or even hundreds of leaves need to be analysed for each study. The aim of this project is to explore the potential of deep learning to save valuable time during the segmentation step. The methodology developed during this internship will be rapidly applied, and the results are likely to be highlighted in several publications in the near future. Large datasets of segmented images are already available within the hosting teams to successfully complete the project.



Context

At the Jean-Pierre Bourgin Institute of Research for Plant Sciences (IJPB-INRAE), located in the exceptional environment of the Château de Versailles park, you will join an internationally renowned research centre in the field of plant biology, which is part of the University of Paris-Saclay. This project is part of a multidisciplinary fundamental research initiative aimed at understanding the biological mechanisms involved in shaping the shape of organs during their development, in particular the serrated leaves of the model plant Arabidopsis thaliana. You will be supervised by an engineer and a researcher from the Modelling and Biological Imaging (MIN) team. The MIN team includes computer scientists and mathematicians and works closely with the Transcription Factors and Architecture (FTA) team, which generates the data to be analysed during this internship. You will also interact with a PhD student who will eventually use the tools developed during this internship.

Objectives

- Conduct a literature review of 2D biological image segmentation methods using deep learning approaches.
- Propose one or more promising strategies that match with our objectives for leaf segmentation.
- Implement the proposed strategy(ies).
- Prepare the available data.
- Apply the implemented method(s) to the prepared data.
- Evaluate the results.

Profile and Skills

A student in the final year of an engineering school or in a master's degree (Bac+5), in one or more of the following disciplines: Computer Science, Data Science, Artificial Intelligence, or Applied Statistics/Mathematics

- Knowledge of Python programming.
- Machine learning experience.
- Experience with deep learning frameworks such as TensorFlow or PyTorch.
- Knowledge of image processing will be appreciated.
- Analytical thinking, autonomy, ability to work collaboratively.
- Interest in research, particularly interdisciplinary research.

Details

Start: From January 1, 2025
End: No later than August 31, 2025
To apply: Send your CV and cover letter to sandrine.lefranc@inrae.fr ou jasmine.burguet@inrae.fr

References

[1] Biot, E., Cortizo, M., Burguet, J., Kiss, A., Oughou, M., Maugarny-Calès, A., Gonçalves, B., Adroher, B., Andrey, P., Boudaoud, A., & Laufs, P. (2016). Multiscale quantification of morphodynamics: MorphoLeaf software for 2D shape analysis. *Development*, 143 (18): 3417–3428.

[2] Oughou, M., Biot, E., Arnaud, N., Maugarny-Calès, A., Laufs, P., Andrey, P., & Burguet, J. (2023). Model-based reconstruction of whole organ growth dynamics reveals invariant patterns in leaf morphogenesis. *Quantitative Plant Biology, 4*, E1. doi:10.1017/qpb.2022.23