Research internship position 2026

Robust label propagation through time-varying 3D point clouds for organ-level growing plant phenotyping

Host team: IGG (Informatique Géométrique et Graphique, *Geometry and Computer Graphics Group*), **ICube** (Laboratoire des sciences de l'ingénieur, de l'informatique et de l'imagerie, *Engineering science, computer science and imaging research institute*), Université de Strasbourg

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Starting date: from February 2026

Ending date: 6 months from the starting date

Funding: about 570 € per month, net salary

Prerequisites: image processing or synthesis, computer vision, machine learning

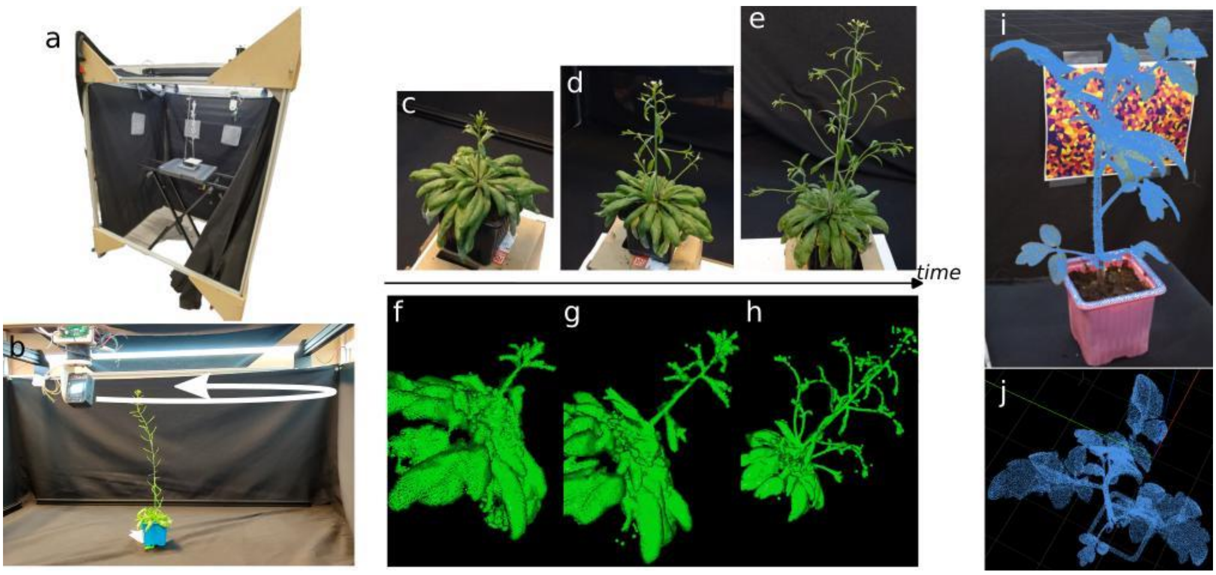

Figure 1 Phenotyping growing plants. (a,b) Overview of the low-cost phenotyping platform developed in RDP/ENS Lyon (a: global, b: inside showing the camera rotating around the plant). (c-e) Time sequence of a growing *Arabidopsis Thaliana* plant and (f-h) corresponding 3D point cloud. (i,j) 3D reconstruction of a tomato plant: the generated 3D point cloud is overlaid on a raw acquisition image (i) or is shown from a virtual top view (j).

Context and problem statement

The subject of this internship falls within the scope of the ANR project 4DPlants [4DPlants] funded by the French Ministry of Higher Education and Research, which involves partners from ICube/Université de Strasbourg, RDP/ENS Lyon, and Inria Grenoble. The overall objective of the 4DPlants project is to develop new methods for the semantic and instance segmentation of time-varying photogrammetry 3D point clouds of growing plants for high throughput phenotyping applications (Figure 1). A key part of the project is to craft training data for a Deep Learning based method aimed at predicting procedural plant representations. Those training data should be obtained from real datasets with annotated organs at each time step. The high-level of expertise and time required to produce such annotations make a manual approach intractable. This internship focuses on the following problem: Given a temporal sequence of 3D point clouds $\{P_1, P_2, \ldots, P_N\}$ of a growing plant, and provided semantic and instance segmentation of the plant organs at each time step, automatically propagate consistent segmentation labels through the whole point cloud sequence. The method must be robust to fine branching structures and organ events, including the appearance of new organs, that lead to new semantic or instance labels, as well as the change or loss of some other ones (e.g., buds opening, or leaf senescence). To ensure scalability, the method should be efficient in terms of time and memory consumption, and as automatic as possible.

A large body of work addresses the segmentation of 3D point clouds of plants [SWW+25, DZQ+25]. Most recent methods are based on Deep Learning and require large training annotated datasets, making them unsuitable for this project. We target a weakly supervised approach and essentially focus on topological and geometric methods. The method by Mirande et al. [MGT+22] is graph-based and segments linear organs (stems and branches) and two-dimensional organs (leaves) by computing the local geometric features and spectral features of the neighborhood graphs. The methods by Pan et al. [PHW+21] and [PCC24] rely on multiscale skeletonization and are suitable for the robust registration of fine structures across multiple time steps. However, these methods are not designed for consistent label propagation, nor the detection of organ events. Some recent methods have been introduced to support these features, requiring high-quality segmented point clouds in input, such as the works by Li et al. [LLX+24] and Li et al. [LAW25].

Objective and work plan

The goal of this internship project is to investigate and develop a robust processing pipeline for temporal sequences of 3D point clouds of plants in 2 stages: 1) The skeletonization, segmentation, and registration of the 3D point clouds of a given sequence; 2) The computation of consistent correspondences between organs across the time steps, including the detection of organ events. To achieve this goal, the work will mainly include two stages:

– The first stage will consist in adapting and evaluating skeletonization and segmentation methods by Mirande et al. [MGT+22] and Pandey et al. [PCC24], considering them as dual processes, offering potential complementarity.

– The second stage will consist in evaluating the methods by Li et al. [LLX+24] and [LAW25] for computing correspondences between organs and detecting organ birth or death events.

The methods will be evaluated on datasets of growing plants acquired in the context of the 4DPlants project (e.g. *Arabidopsis Thaliana* specimens) as well as on publicly available datasets.

The trainee will be given access to a desktop computer and computing resources.

References

[4DPlants] https://4dplants.icube.unistra.fr/

[DZQ+25] R. Du, G. Zhai, T. Qiu, Y. Jiang. Towards scalable organ level 3D plant segmentation: Bridging the data algorithm computing gap. arXiv preprint arXiv:2509.06329, 2025

[LAW25] D. Li, F.I Ahmed, Z. Wang. 3D-NOD: 3D new organ detection in plant growth by a spatiotemporal point cloud deep segmentation framework. Plant Phenomics, Volume 7, Issue 1, 100002, 2025, doi : 10.1016/j.plaphe.2025.100002

[LLX+24] D. Li, L. Liu, S. Xu, S. Jin. TrackPlant3D: 3D organ growth tracking framework for organ-level dynamic phenotyping. Computers and Electronics in Agriculture, Volume 226, 109435, 2024, doi: 10.1016/j.compag.2024.109435

[MGT+22] K. Mirande, C. Godin, M. Tisserand, J. Charlaix, F. Besnard and F. Hétroy-Wheeler. A graph-based approach for simultaneous semantic and instance segmentation of plant 3D point clouds. Front. Plant Sci., 13:1012669, 2022, doi: 10.3389/fpls.2022.1012669

[PHW+21] H. Pan, F. Hétroy-Wheeler, J. Charlaix and D. Colliaux, Multi-scale Space-time Registration of Growing Plants. 2021 International Conference on 3D Vision (3DV), London, United Kingdom, pp. 310-319, 2021, doi: 10.1109/3DV53792.2021.00041

[PCC24] S. B. Pandey, D. Colliaux and A. Chaudhury, Spatio-Temporal Correspondence Estimation of Growing Plants by Hausdorff Distance based Skeletonization for Organ Tracking, 2024 IEEE International Conference on Robotics and Automation (ICRA), Yokohama, Japan, pp. 13625-13631, 2024, doi: 10.1109/ICRA57147.2024.10610490

[SWW+25] H. Song, W. Wen, S. Wu, X. Guo. Comprehensive review on 3D point cloud segmentation in plants. Artificial Intelligence in Agriculture, Volume 15, Issue 2, Pages 296-315, 2025, doi: 10.1016/j.aiia.2025.01.006