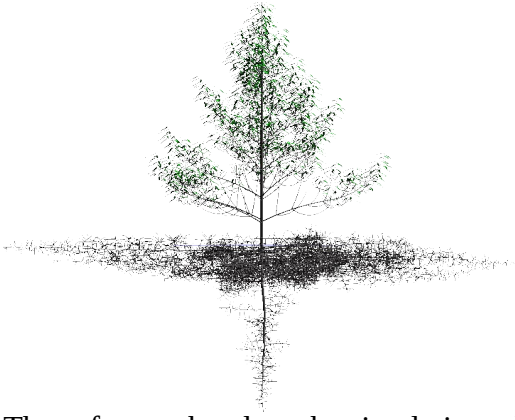
Estimating parameter values of a plant growth model with a Neural network

General overview (http://amapstudio.cirad.fr/soft/rococau/start)

RoCoCau is a plant growth simulator that can produce the 3D shape of a realistic plant along time. It takes into account both stem and root part of the plant. The kind of output it produces looks like :



or

The software that does the simulation takes benefit of an architecture that allows to add plugins to the default kernel. Plugins can affect the default behavior of the simulation taking into account functional hypothesis.
TOY is a functional plugin that expresses the dependency between roots and shoots. It assumes that sugar is produced thanks to the carbon taken in the air by leaves, thanks to the water taken in the soil by roots and thanks to the energy captured from light by leaves. It also assumes that plants are constantly balancing both compartments growth so that they can homogeneously contribute to further sugar production. To do so, sugars are shared in opposite proportion of contribution (the compartment that contributes the more (carbon or water) receives the less (sugar)). Growth is modulated according to a simple rule that drives death, branching and apical growth as a function of growth rate (ratio between actual available compartment sugar and maximum available sugar in case of optimal environment).

A plant grown in optimal conditions(RoCoCau+TOY)

same plant with water stress(RoCoCau+TOY)

Internship

The aim of this internship is to assess calibration tools of the TOY module parameters using deep learning methods applied on simulated plants databases. Some results were already obtained [1] using the Voxnet convolution network (https://ieeexplore.ieee.org/document/7353481). Based on these results, the student will have to propose improvements about the flowchart of data processing both applied on network structure, on input/output and on the distance measurement for learning process.

Internship will last 6 month preferably beginning in march 2023 and take place at Amap. Daily allowance and company restoration are included.

Required level of knowledge: Master degree or equivalent. Computer science specialty in machine learning. Very good knowledge of Python language is required. A first touch about neural networks and dedicated software environment (pytorch, tensorflow) is necessary.

Supervision: Internship will take place in Montpellier (France) at UMR AMAP (http://amap.cirad.fr). The candidate will be supervised by JF Barczi (barczi@cirad.fr) for the plant growth modeling and simulation topic [2] and by Philippe Borianne (borianne@cirad.fr) for the neural network topic [3].

References

[1] Masson A.L., Caraglio Y., Nicolini E., Borianne P., Barczi J.F. (2021) Modelling the functional dependency between root and shoot compartments to predict the impact of the environment on the architecture of the whole plant: methodology for model fitting on simulated data using Deep Learning techniques. *in silico Plants*, Volume 4, Issue 1, 2022, https://doi.org/10.1093/insilicoplants/diab036

[2] Barczi, J. F., Rey, H., Caraglio, Y., De Reffye, P., Barthélémy, D., Dong, Q. X., & Fourcaud, T. (2008) AmapSim: a structural whole-plant simulator based on botanical knowledge and designed to host external functional models. Annals of Botany, 101(8), 1125-1138.

[3] Borianne, P., Borne, F., Sarron, J., & Faye, E. (2019). Deep Mangoes: from fruit detection to cultivar identification in color images of mango trees. arXiv preprint arXiv:1909.10939.