PHD FELLOWSHIP OFFER

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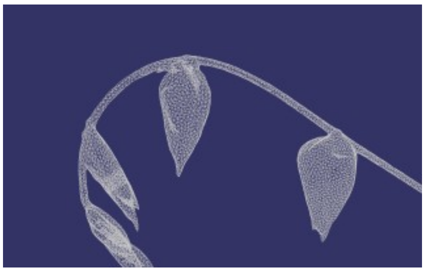
Funding: YES (PhD funded by ENS Lyon)

keywords: biophysics, biomechanics, plant growth, plant movements, 3D reconstruction, modeling.

Biophysical study of plants' morphogenetic motions



Plants do move ! And they move a lot when observed at the appropriate timescale. Although plants movements were already observed as early as 400 years before common era by Androsthenos of Thasos (an admiral of Alexander the Great who reported about the ``sleep movements" of the tamarind's leaflets) and later popularized by Darwin, the active motions of plants have never been carefully exploited. This is a shame because the motion of plants is intimately linked to their growth pattern, and therefore, is an important witness to question.

This PhD project aims for the first time, to combine **3D tracking and quantification of plant movements and mechanics with biophysical modeling**. Our ambition is to get insights about the very process of plant growth itself, and find out about the posture regulation processes in plant developments. The PhD student will perform experiments on different kind of leaves: compound leaf and simple leaves which exhibit different kinds of stereotyped motions during unfolding.

We already did an exhaustive description of typical movements exhibited by a compound leaf (*Averrhoa carambola*) [Rivière, 2017; Rivière, 2020; Meroz, 2020]. Mathematically it can be represented by a 1D curve embedded in a 3D space and it will be modeled using rod based elasticity theories. The most interesting aspects of the motion involve the regulation of the posture (straightening of the leaf) associated to a fast (2 hours period) nutation motion [Rivière, 2021]. Second, the avocado tree (*Persea americana*) is a typical simple leaf, which is mathematically represented by a 2D surface embedded in the 3D space. For this kind of object, elasticity theory of shells will be needed. We already evidenced a peculiar motion during development: a buckling of the lamina is associated to the swinging of the midrib of the leaf [Derr, 2018]. The resulting motion is counter-intuitive, and will only be explained by invoking mechanosensitivity [Moulia, 2021].

The key point of this project is that these rich motions associated to plant development are essentially 3D and therefore need to be quantitatively tracked in 3D. The PhD student will collaborate with computer scientists to obtain quantitative growth field of the leaf. The PhD student will be involved in the experimental work to obtain kinematics and residual strains of the plants: Kinematics will be performed thanks to a multi-camera setup which concept has already been proven in a preliminary project [Robin, 2017] (see figure for an example of 3D reconstruction). Residual strains will be observed thanks to the development of a new experimental setup enabling to see how the plant relax after releasing locally the stress by micro-surgical manipulation.

By comparing and correlating real growth field, and prescribed growth field (deduced from residual strain), as a function of plant leaf development, we expect to infer general mechanosensitivity laws. The PhD student will collaborate with physicists and to test biophysical models in order to reproduce the observations and ultimately enable the discrimination between different mechanosensitivity hypotheses [Derr, 2018]. Finally the PhD student will benefit from the rich biological environment of the RDP lab to use the 3D imaging set up on various perturbed plants to get further biological insights.

The project is strongly multi-disciplinary, and the PhD student will work in close collaboration with physicists, computer scientists, mathematicians, and biologists.