Research Topic for the ParisTech/CSC PhD Program

Subfield: Physics, Biology

ParisTech School: ESPCI

Title: Interaction of a plant root with mechanical obstacles

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Short description of possible research topics for a PhD:
The mechanical properties of a soil like the packing fraction and the distribution of void sizes greatly affect the development of a plant root, which in turn affects the shoot development. In particular, plant roots growing in heterogeneous medium like sandy soils or cracked substrates have to adapt their morphology and exert radial and axial forces depending on the pore size in which they penetrate or the mechanical obstacle they encounter. To study such soil/root interaction we examine root penetration in model experimental systems mimicking the passage inside a pore or the encounter with a mechanical obstacle of known rigidity.
The subject of root-soil interaction is at the interface between biology and physics. We are interested in the changes of the pattern of root growth and architecture resulting from the mechanical stresses exerted by the soil. This work will be done in a physics lab (PMMH-ESPCI) in collaboration with biologists from INRA Nancy (UMR EEF) and INRA Clermont-Ferrand (PIAF), as well as from the James Hutton Institute in Scotland.

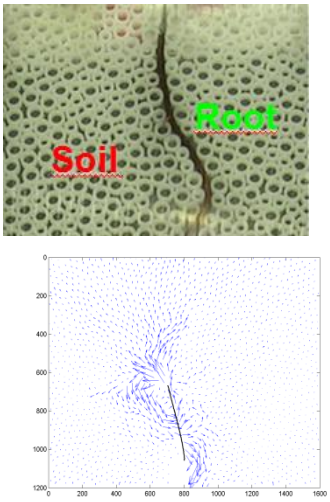

Fig. 1: Top: Root's growth inside a 2D granular medium. The root's diameter is comparable to the grain sizes (a few mm). Bottom: Displacement fields of grains induced by the penetration of a flexible fiber.

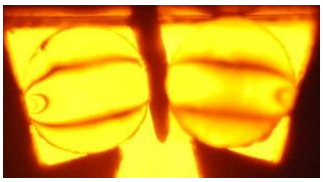

Fig. 2 : Growth of a chick-pea root (ø ≈1 mm) between 2 photoelastic disks placed between circular polarizers. The radial growth of the root in the 2D constriction leads to the appearance of photoelastic fringes, whose location and numbers are related to the root radial force.

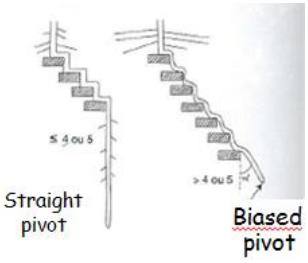

Fig. 3: Schematic of the root's growth in an assembly of shifted obstacles [from Institute for the Forest development]. Different growth paths and root architecture are possible depending on the number of obstacles.

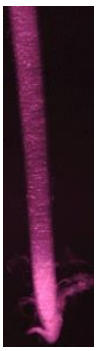

Fig.4 : Imaging of a root in near infra-red [from PhD thesis of F. Bizet, 2014. Nancy] to follow the local growth rate in the root's elongation zone.

Required background of the student: Experimental physics

A list of 5 (max.) representative publications of the group: (Related to the research topic)
Kolb, Hartmann, Genet, 2012, *Plant Soil* 360, 19-35
Kolb, Legué, Bogeat-Triboulot, 2017, *Phys. Biol.* https://doi.org/10.1088/1478-3975/aa90dd