

Link between skin's microstructure and mechanical properties using quantitative image analysis on multiphoton images

Collagen and elastin fibers, organized as patchworks of intertwined fibers, play an essential role in the biomechanical response of soft tissues such as human skin. Morphological and image analysis tools, coupled to multiphoton microscopy techniques, have been developed in an effort to capture the multiscale characteristics of the fibers, including their spatial and orientational distribution [1,2].

This research internship is a joint partnership between *L'Oréal Research and Innovation* (T.Baldeweck) and the *Centre for Mathematical Morphology* of *MINES Paristech* (E.Decencière, P.Dokládál and F.Willot). The ultimate goal of the collaboration is to determine the right microstructural targets to modulate the overall macroscopic mechanical properties of skin.

The internship project's goal is to develop quantitative characteristics and morphological criteria relevant to the organization of the network of collagen and elastin fibers at various scales, based on 3D multiphoton images [2,3]. These microstructural markers will then be confronted to macroscopic mechanical measurements (storage and loss moduli) on skin to determine their relevance in skin mechanics.

Duration: 4 to 6 months.

Gratification: minimal salary (French SMIC).

Location: Centre for Mathematical Morphology, MINES-ParisTech, 35, rue Saint Honoré, 77300 Fontainebleau

How to apply: candidates with excellent scientific background, used to Python, and with medium to advanced knowledge of image processing and/or mechanics, should send a *CV*, *motivation letter*, *list of courses* and *grades*, and any other relevant document (pdf format preferred) to Etienne.Decenciere@mines-paristech.fr.

References

- [1] Bancelin, S., Lynch, S., Bonod-Bidaud, C., Ducourthial, G., Psilodimitrakopoulos, S., Dokládál, P., Allain, J.-M., Schanne-Klein, M.-C., Ruggiero F. Ex vivo multiscale quantitation of skin biomechanics in wild-type and genetically-modified mice using multiphoton microscopy. *Scientific Reports* 5.17635 (2015).
- [2] Bancelin, S., Nazac, A., Haj Ibrahim, B., Dokládál, P., Decencière, E., Teig, B., Haddad, H., Fernandez, M.-C., Schanne-Klein, H., De Martino, A. Determination of collagen fiber orientation in histological slides using Mueller microscopy and validation by second harmonic generation imaging. *Optics Express* 22.19 (2014): 22561–22574.
- [3] Frangi, A.F., Niessen, W.J., Vincken, K.L., Viergever M.A. Multiscale vessel enhancement filtering. In: *International Conference on Medical Image Computing and Computer-Assisted Intervention*. Springer, Berlin, Heidelberg, 1998. pp. 130-137.
- [4] Suquet, P. On the effect of small fluctuations in the volume fraction of constituents on the effective properties of composites. *Comptes Rendus Mecanique* 333.3 (2005): 219-226.