PhD position at the Center for Biomedical and Healthcare Engineering,
ARMINES/Mines Saint-Etienne – Laboratoire Georges Friedel (UMR CNRS-5307)

ENRICHED COMPUTATIONAL APPROACH FOR MODELLING LOCALIZATION IN BLOOD VESSELS

Keywords: Non local mechanics, modelling, localization, mechanobiology, aneurysm

Academic context: This PhD position is part of the interdisciplinary Biolochanics - Localization in biomechanics and mechanobiology of aneurysms: Towards personalized medicine - project (2015-2020) awarded to Stéphane Avril (http://www.mines-stetienne.fr/stephane-avril) under the European Research Council Consolidator Grant scheme (http://erc.europa.eu/consolidator-grants). His group at Mines Saint-Etienne leads major international research projects in the domain of soft tissue biomechanics, focused especially on aortic aneurysm through a longstanding collaboration with the Saint-Etienne University Hospital. The Biolochanics project also relies on collaborations with Yale University (USA).

Scientific context: Localization in nonlinear solid mechanics refers to a material instability phenomenon where small perturbations of loading lead to disproportional localized strains. This is the kind of constitutive behavior that typically precedes fracture and it occurs in a number of problems related to engineering applications. This PhD thesis will develop ground-breaking approaches to model localization for the first time ever in the context of aneurysm growth and rupture, permitting to achieve patient-specific predictions of aneurysm rupture and contributing to enable localized repair of aneurysm structure.

Project summary: Our group was recently able to detect, in advance, at the macroscopic scale, rupture-prone areas in bulging aneurysmal arterial tissues. These state-of-the-art results indicate that rupture follows a localized strain concentration. The next step is to introduce localization in the models. For this, an important theoretical problem has to be addressed: calculating the post-localization stress and strain distributions in a hyperelastic tube subjected to different loadings and to growth and remodeling situations. In order to reach the post-localization regime and to handle mesh-objectively the strain concentration, a non-local formulation within a geometrically non-linear setting will be implemented in the models. The work involves first developing the theoretical framework for this nonlocal formulation, its validation on simple cases (flat membranes in simple and biaxial tension) and then the implementation in a finite element analysis. Finally, numerical predictions will be compared to the currently available experimental results on real aneurysms in order to calibrate the internal length-scale parameters required in the nonlocal models.

Student profile: Computational mechanics or mathematics. Background in finite element analysis and/or good knowledge of continuum mechanics will be appreciated. Motivation for ground-breaking theories and for computational work is required. Interest in mechanobiology.

Administrative aspects: The employer is Armines, linked by state-approved agreements to Mines Saint-Etienne, one of the most prestigious engineering schools in France. This PhD is funded for 36 months, starting in Fall 2015. The PhD will be under the supervision of Stéphane Avril and Claire Morin (Mines Saint-Etienne).

If you are interested, send a curriculum vitae, a cover letter describing previous research experience and interests, the names and contact information of two references. Please, submit via email with "ERC Biolochanics PhD1" on the subject line to Prof Stéphane AVRIL, PhD (avril@emse.fr).