PROPOSAL FOR A MASTER RESEARCH PROJECT

Data-driven computational mechanics

Field Computational mechanics, numerical methods (finite element)

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Motivation Typical problem in computational mechanics considers the response of a solid deformable body under applied loading, leading to the boundary value problem. In this context we are interested in computing three fields : displacements, strains and stresses, which are in agreement with prescribed mechanical properties, applied external loading and the conditions imposed on the boundary. These three fields are defined with three types of equations, (i) kinematics equations, which describe the dependence of the strain field on the displacement field ; (ii) equilibrium equations, relating the stress field and the external loading, and (iii) constitutive equations, linking the stress field to the strain field. While (i) and (ii) are well known and universal, related to either geometry or conservation laws, one of the fundamental issues that scientists and engineers are confronted with is the characterization of the mechanical behaviour of material, given with (iii). This is where we need *data* to calibrate our computation (keeping in mind that the predictions are as good as the calibration, and never better). Traditional approach in computational mechanics considers the formulation of material models (like plasticity) based on fitting of some kind. These models are empirical, tend to be as simple as possible (potenitial loss of data) and have a limited predictability mostly because the true material behaviour is usually interaction of very complex multiscale (in space and time) mechanisms.

Objective Recent advances in computational power on one side and diagnostics, microscopy and experimental mechanics on the other, enabled to generate terabytes of useful *data* which characterizes the material behaviour. That is why we seek to come back do data and use it in computation directly. The objective of this internship is to explore and develop an alternative way in computational mechanics with the goal of maximizing the use of data in calculation. That is, to keep material independent general laws (i) and (ii) unchanged, while using the raw (unprocessed and thus lossless) data to drive the computation. As opposed to traditional approach based on constitutive law given as the mapping (of, *e.g.*, strain to stress), data-driven approach is based on a data set with all the possible states given as a set of points (*e.g.* measurements).

Expected outcome Formulation of data-driven approach in computational mechanics, numerical implementation (computational code) for 1D and 2D elasticity, performing tests of numerical convergence and robustness.

Pre-requisites Mandatory : programming (algorithm and coding)

Duration 6 months

Remuneration Typical internship (around 530 EUR/month)

References

T.Kirchdoerfer, M.Ortiz, Data-driven computational mechanics, *CMAME* 304 (2016) 81–101