Proposition de thèse de doctorat

Début : 2017-2018

Titre de la thèse : Développement d'approches de simulation numérique sans modèle pour la mécanique non-linéaire des matériaux

Laboratoire : GeM

Equipe : MS+PMM

Localisation de la thèse : ECN

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Description du sujet

The objective of the thesis is to explore ways to perform numerical simulations from a database of material mechanical response (stress, strain, potentially inelastic strains). To this end, the balance equations are solved using a standard solution algorithm like implicit Newton's iterative solver, while numerical techniques are elaborated to interrogate the feature database for admissible features values. Two methodologies are followed:

1. interpolation: efficient strategies for large database of high-dimensionality like sparse interpolation are used. They may be combined with local regression for the evaluation of the derivatives (tangent operators required by the solution algorithm).

2. regression: the manifolds of the defined features are parametrized providing for an efficient interrogation of the database as well as computation of the tangent operators.

It is expected that a by-product of the projection/regression process described above will be an estimation of the associated approximation error. An open question is the extrapolation of the data to experimentally unexplored materials and its ability to suggest new experiments. In the case of multi-scale analysis, like for composite materials, it will possible to combine experimental data with numerically generated data to enrich the database.

An alternative approach will also be considered, using purely data-driven solution strategies, in the spirit of those found in [KIR16, IBA16]. Using a data-driven solver, the distance to the data is minimized under equilibrium constraints. The main challenge is to extend existing works to nonlinear materials with internal variables introducing dependency to loading history (like for plasticity or damage). Data-driven solution strategies have been recently developed and their behavior with respect to noise or sparsity of the database has not yet been analyzed. The data-driven formalism gives us the opportunity to solve inverse problems to find the optimal database [LEY17]. This methodology further enforces the link between experiments and numerical simulations. A improved robustness is expected. As above, an open question is concerned with missing data and the ability of the method to guide the user for improving the database.

[IBA16] Ibañez, R., Abisset-Chavanne, E., Aguado, J. V., Gonzalez, D., Cueto, E., & Chinesta, F. A Manifold Learning Approach to Data-Driven Computational Elasticity and Inelasticity. Archives of Computational Methods in Engineering, 1-11.
[KIR16] Kirchdoerfer, T., & Ortiz, M. (2016). Data-driven computational mechanics. Computer Methods in Applied Mechanics and Engineering, 304, 81-101.
[LEY17] Adrien Leygue, Julien Réthoré (2017). Data-driven constitutive identification. To be submitted. Available on https://hal.archives-ouvertes.fr/hal-01452494 .

Compétences requises
Mécanique non-linéaire des solides, Méthodes numériques (MEF, ...)

Commentaires Supplémentaires
Etude en relation Financement prévu : Indemnité : Oui (pour les étudiants non déjà boursiers) Montant net mensuel envisagé :