A "ROM+DDCM" framework for thermo-mechanical simulations

N. Blal *, A. Gravouil*

* Univ Lyon, INSA-Lyon, CNRS UMR5259, LaMCoS, F-69621, France
e-mail: nawfal.blal@insa-lyon.fr, anthony.gravouil@insa-lyon.fr

ABSTRACT

Thanks to the significant advances in data sciences and numerical algorithms, and face to the current industrial and societal challenges, Physically-based data-driven computational modeling would have an important role in simulations based design for the development of innovative materials and new products. With the new paradigm of data Driven Computational Mechanics proposed by [1], the constitutive laws can be directly replaced by a collection of experimental data avoiding thus the crucial step of proposing a mathematical model that best fit the experiments and calibrating its inherent parameters. The DDCM bypasses the empirical constitutive laws and searches the solution as a double distance minimizing problem between the physical space (respecting thus the physical universal laws) and the material data manifold (discrete set of data points with no explicit mathematical model).

Despite the recent applications of DDCM algorithms in numerical simulations, their practical using still remains limited to reversible behaviors and their extension to irreversible dissipation problems needs further developments. Moreover, the data generation phase needs more efforts to reduce its high (numerical or experimental) cost. We propose in this study a strategy that makes the most of Reduced Order Models (ROM) and Data Driven Computational Modeling (DDCM) to extend such a free material paradigm to more complicated problems, namely irreversible and multi-scale simulations. The application of the "ROM+DDCM" framework will be illustrated for a 2D elasto-plastic problem and 3D multiscale thermal simulations. A tangent space based double distance algorithm is adopted for the DDCM [2] algorithm and the HOPGD [3] method is used for the ROM step.

REFERENCES

[1] T. Kirchdoerfer, M. Ortiz, Data-driven computational mechanics, Computer Methods in Applied Mechanics and Engineering 304 (2016) 81 – 101.

[2] DKN. Pham, N. Blal, A. Gravouil, Tangent space Data Driven Framework for elasto-plastic materials behaviors, Finite Element in Analysis and Design 216 (2023) 103895.

[3] Y. Lu, N. Blal, A. Gravouil, Adaptive sparse grid based HOPGD: Toward a nonintrusive strategy for constructing space-time welding computational vademecum, International Journal for Numerical Methods in Engineering 114 (13) (2018) 1438–1461.