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Reduced Basis method applied to large scale non linear multiphysics problems

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The Laboratoire National des Champs Magnétiques Intenses (LNCMI) is a French large scale facility [2] enabling researchers to perform experiments in the highest possible magnetic field. The design and optimization of such magnets require the prediction of performance metrics which can be the magnetic field in the center, maximum stresses, or maximum and average temperatures. These outputs are expressed as functionals of field variables associated with a set of coupled parametrized PDEs involving materials properties as well as magnet operating conditions. These inputs are not exactly known and form uncertainties that are essential to consider, since existing magnet technologies are pushed to the limits.

Solutions of a multi-physics model involving electro-thermal, magnetostatics and mechanics are requested to evaluate these implicit input-output relationships, but represent a huge computational time when applied on real geometries. The models typically include mesh (*resp.* finite element approximations) with (tens of) millions of elements (*resp.* degrees of freedom) requiring high performance computing solutions. Moreover, the non affine dependance of materials properties on temperature render these models non linear and non affinely parametrized.

The reduced basis (RB) method offers a rapid and reliable evaluation of this input-output relationship in a real-time or many-query context for a large class of problems among which non linear and non affinely parametrized ones. This methodology is well adapted to this context of many model evaluations for parametric studies, inverse problems and uncertainty quantification.

In this talk, we will present the RB method applied to the 3D non-linear and non affinely parametrized multi-physics model used in a real magnet design context. This reduced model enjoys features of reduced basis framework ([3, 1]) available with opensource library Feel++. (Finite Element method Embedded Language in C++, `http://www.feelpp.org`). Validations and examples will be presented for small to large magnet models, involving parametric studies and uncertainty quantifications.

References

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