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Méthode d'approximation par bases réduites pour l'approximation d'EDP nonlinéaires : introduction, estimation a posteriori et applications

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Numerical approximation of the solution of partial differential equations plays an important role in many areas such as engineering, mechanics, physics, chemistry, biology. The relevance of the numerical solution strategy relies on faster numerical algorithms and improved discretization methods. In many situations, including optimization and control, the same model, depending on a parameter that is changing, has to be simulated over and over, multiplying by a large factor (up to 100 or 1000) the solution procedure cost of one single simulation.

The reduced basis method allows to define a surrogate solution procedure, that, thanks to the complementary design of fidelity certificates on outputs, allows to speed up the computations by two to three orders of magnitude while maintaining a sufficient accuracy. We shall first present the basics of this approach for linear elliptic and parabolic PDE's.

The extension to non linear problems (the only one that are of real interest) is based on an ad'hoc interpolation method that is interesting per se for other type of applications. The basics of the method, its implementation and the results concerning its analysis will be presented.

Finally, a new method that allows to combine the reduced basis feature with a two grids approximation finite element method will be presented. This strategy allows in particular to use the reduced basis method in a frame of industrial software in a non invasive way.