Hyper-Reduction method for mechanical contact problems

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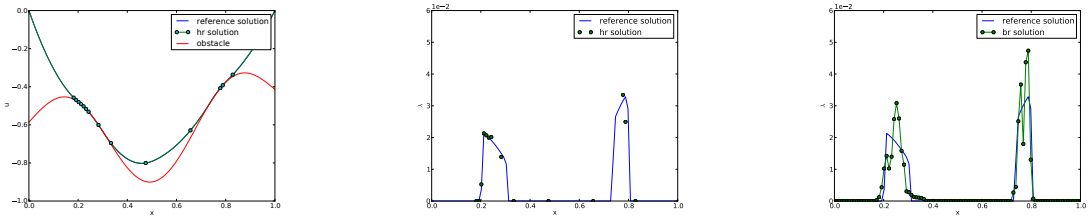
ABSTRACT

The computation of partial differential equations (PDEs) can be expensive using the finite element (FE) method. The discretized system dimension directly depends on the domain discretization. To tackle this problem, some techniques based on reduced-order basis (ROB) have been developed and generalized to various systems. The reduced system is obtained by projecting the initial PDE on the ROB. Then the solution space is restricted to a smaller subspace.

We focus here on the model reduction of mechanical problems involving contact, numerically solved using Lagrange multipliers physically representative of contact forces. Some methods have already been proposed like in [1, 2]. However, neither of these techniques enable to obtain a well suited ROB for Lagrange multipliers.

In this paper, we propose to extend another model reduction method called hyper-reduction [3] (HR) to contact problems. The HR is also based on ROB but furthermore solves the projected problem on a reduced integration domain (RID). This strategy accelerates even more the computational time of the simulation especially for non-linear problems. When using HR method on contact problems, no Lagrange multipliers ROB is required because the number of contacts is naturally reduced by the RID. Indeed, only the contacts in the RID are treated.

This strategy has been applied with success to two reference 1D elastic problems with contact. Compared to the methods of the literature, the HR enables us to obtain very satisfactory contact forces approximation while saving computational time. Meanwhile, the reconstruction of the contact forces outside the RID brings us back to the problem of finding a reliable ROB.



(a) HR positions and obstacle (b) HR contact forces (c) RB contact forces

Figure 1: Hyper-reduced solution

We also proposed a simple but efficient error indicator to choose pertinent snapshots. This opens the way to apply the HR-contact strategy to much more complex industrial problems.

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