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High-order fictitious domain methods for thin structures

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Fictitious domain methods have recently gained more attention because of their favourable properties to conduct design-through analysis. Albeit known for decades[1], they have been recently revisited in the context of higher order methods such as the Finite Cell[2] or the X-FEM[3], retaining the advantages of both approaches (exponential convergence for smooth solutions without meshing burden). The efficiency of such methods has been highlighted in numerous contributions. Here we propose to study the application of high-order fictitious domain methods for thin structures. This would avoid complex mesh manipulations to extract shell models, stress concentrations near model transitions and give the opportunity to use classical nonlinear models. However, relying on a pure displacement formulation can also lead to locking phenomena. Furthermore, thin problems are difficult to handle for fictitious domain methods, due to prohibitive integration costs.

We propose here to rely on a high-order approximation that has been proved efficient in the context of solid-shell strategies [4]. Concerning the integration cost, an efficient strategy, based on anisotropic mesh adaptation is developed in order to decrease the integration cost.

The method is validated through multiple examples to highlight its performances for: (i) Integration cost; (ii) Locking sensitivity and (iii) Condition number. The method is shown to be robust for both 2D and 3D benchmarks, but also for realistic problems[5].

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