6th European Conference on Computational Mechanics (ECCM 6)
7th European Conference on Computational Fluid Dynamics (ECFD 7)
11-15 June 2018, Glasgow, UK

Stabilization method for contact problems under the Cartesian Grid-based Finite Element method framework

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Keywords: *Immersed boundary, Cartesian grid, Stabilization, Contact problems*

When using Immersed Boundary methods, such as the Finite Cell Method [1] or the Cartesian Grid Finite Element Method (cgFEM) [2] for solving the elasticity problem, some nodes are outside of the problem domain with a small associated stiffness in comparison to the nodes placed into the problem domain. This characteristic issue of the Immersed Boundary methods yields ill-conditioning problems when solving the global system of equations. The main reason behind this behaviour is the fact that the energy contribution of the pathological nodes is small, therefore the global energy of the problem is only slightly affected by the solution of these nodes.
The proposed method adds an extra term to the formulation that stabilizes the solution of those pathological nodes. This new term consist of *i*) a stiffness-type matrix involving only to these nodes, which value is related to the element size, for the LHS of the system and *ii*) a force directly applied to these nodes. The cgFEM method requires an iterative process to impose the Dirichlet boundary conditions [3]. This iterative process is used to evaluate the force required for the stabilization term, from the solution of the previous iteration. Therefore, the stabilization procedure does not add any extra computational cost to the already existing process. The results show an improvement of the system matrix condition number and thus, a better performance of the iterative solvers. Additionally, in the case of contact problems the ill-conditioning of the system matrix prevented the convergence for the contact problem. The numerical results show that the addition of the proposed stabilisation term allows to solve this kind of problems.

Acknowledgments With the support of Ministerio de Economía, Industria y Competitividad of Spain (DPI2017-89816-R) and the Generalitat Valenciana (PROMETEO/2016/007).

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