Università degli Studi di Pavia

Computational Mechanics & Advanced Materials Group - DICAr

SEMINAR

Validation of an immersed methodology for FSI using NURBS and T-splines

In the last decades, several modelling and simulation techniques for Fluid-Structure Interaction (FSI) problems have been designed. An FSI problem that has attracted considerable attention is that of a incompressible viscous fluid containing various immersed deformable solids. In the 1970's, Peskin [1] developed the Immersed Boundary (IB) method to study this kind of problems and later on this method was enhanced in [2] where the finite element method is utilized for both the fluid and solid mesh and information transfer between meshes is carried out using so-called discretized delta functions.

Few months ago, the IGA framework was applied to this immersed methodology in [3]. In that paper, Non-uniform rational B-Splines (NURBS) are used for both the Eulerian and Lagrangian meshes and also for the information transfer between the meshes. The linear momentum balance and mass conservation equations are solved using a variational multiscale technique and the kinematic equation is solved using a collocation method for the Greville points. Benchmark problems are solved in 2D and 3D achieving very good agreement with the available analytical solution for those cases. The higher-order and especially the higher continuity between elements allow us to deal with severe distortions which is not possible with piecewise linear functions as is shown in our examples. The fluid is governed by the Navier-Stokes equations of viscous incompressible flows and the solids are treated as nonlinear hyperelastic materials, but other material models could be considered.

Recently, we have extended our methodology to T-splines. NURBS have been successfully applied to a lot of different applications in analysis in the last years, but they have some limitations. T-splines have two main advantages against NURBS, they support local refinement and they are unstructured. Local refinament allows us to refine the Eulerian mesh close to the Lagrangian mesh and the unstructured nature of T-splines gives us the opportunity of introducing extraordinary nodes in order to avoid singular points.

[1] Peskin, “Flow patterns around heart valves: a numerical method”, *J. Comp. Phys.*, **10**:252–271, 1972

[2] Zhang, Gerstenberger, Wang, Liu “Immersed finite element method”, *Comp. Meth. Appl. Mech. Eng.*, **193**,:2051–2067, 2004

[3] Casquero, Bona-Casas, Gomez “A NURBS-based methodology for fluid-structure interaction” , *Comp. Meth. Appl. Mech. Eng.*, **284**: 943–970, 2015

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