Non-matching interface treatment for isogeometric B-Rep analysis of light-weight, thin-walled structures coupled to LES

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ABSTRACT

A safe design of light-weight shell and membrane structures with respect to wind is (amongst others) characterized by the treatment of complex free-form shapes, the appearance of large deformations, and the occurrence of potentially critical flow-induced vibration effects. The characteristic of natural wind is very complicated and it is a highly turbulent flow with huge Reynolds number. In order to capture properly the relevant flow-induced effects and the transient interaction between structure and wind flow, one needs to couple LES with geometrical nonlinear structural dynamics simulation. To ensure a safe structural design, the simulations need to be representative for the complex physics. This requires a high level of credibility of the computed results and finally enables predictive simulations. To support this high quality of the gained results, one must on the one hand reduce the occurring errors in the solution of each field by using best-suited methods and on the other hand perform validation [3] of the simulation approaches. Both of these points are addressed in the collaborative work which is presented within this contribution. The two groups work on a validation activity comprising the turbulent flow around a flexible hemisphere. The resolution of the complex flow patterns requires (especially around curved shapes) very fine fluid meshes which are typically not needed in the structural field. Moreover, the fluid requires a highly accurate surface description, also in case of large deformations. The latter corresponds well with one of the core ideas of Isogeometric Analysis (IGA), which was proposed by T. Hughes and coworkers in 2005. Typically, real-world geometries are composed of multiple NURBS patches with non-matching parametrizations at their seam lines [2,4] and these complex geometries are built by heavily using trimming operations. The structural analysis on such design models is enabled by the isogeometric B-Rep analysis (IBRA) [1] which is therefore the basis of the presented structural analysis. To enable the coupling to a dedicated and approved LES solver, a non-matching grid treatment between IBRA for thin-walled structures and “classical” fluid discretizations (like FVM and low-order FEM) is elaborated and investigated. A special focus is set on the discussion of peculiarities originating from the multi-patch coupling and the trimming.

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