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Enabling smooth interfaces in FSI by the Isogeometric B-Rep Analysis of shells and membranes

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The analysis and design of light-weight, thin-walled structures, such as wide-span membrane roofs or long and slender wind-turbine blades, which are subjected to wind flows is a challenging task. The computation of the potential wind-induced motions needs a robust and accurate fluid-structure interaction simulation approach which can treat complex free-form shapes of the structure, large structural deformations, and can deal with very diverse resolution requirements meeting at the interface. On the fluid side, 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 eddy-resolving solution approaches with geometrical nonlinear structural dynamics simulation. 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 the deformed configuration. The latter corresponds well with one of the core ideas of Isogeometric Analysis (IGA), which uses the smooth geometry description from CAD. Typically, real-world geometries in CAD are composed of multiple NURBS patches with non-matching parametrizations at their seam lines [1] 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) [2] 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. Potentials of the highly accurate geometry description for the coupling to embedded fluid solvers are also illustrated.

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