Advantages of Combining NURBS-Enhanced Finite Elements and Isogeometric Analysis in the Context of Fluid-Structure Interaction

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ABSTRACT

Computer-Aided-Design (CAD) tools are commonly used during the design stage in many engineering applications. These tools generally make use of Non-Uniform Rational B-Splines or NURBS to represent geometries. The properties of NURBS make them well suited to accurately describe complex shapes. The introduction of isogeometric analysis (IGA) [1] make it possible to directly exploit the favorable geometric properties of NURBS for numerical analysis. Analyzing fluid flows, however, typically involves complex three-dimensional flow domains. Parametrizing such domains using closed volume splines can be challenging and is still an ongoing research topic in the IGA community.

To circumvent the need for volume splines, an alternative approach is proposed in [2], which is further developed to incorporate space-time finite elements and free-surface flows in [3]. The proposed method suggests the use of standard finite elements in the interior of the computational domain and supplementing it with the so-called NURBS-Enhanced Finite Elements (NEFEM) along the domain boundaries. NEFEM use a NURBS description of the domain boundary in order to integrate the exact geometry into the finite element method. By doing so, the error due to conventional discretization of a finite element mesh is avoided.

In [4] the Deforming Spatial Domain/Stabilized Space-Time (DSD/SST) method extended with NEFEM [3] is coupled with a semi-discrete IGA solver in a partitioned way. This leads to a geometrically exact interface and simplifies the data transfer between the solvers involved. Finally, an error reduction can be achieved. In the current work, we apply the described method to FSI problems involving incompressible and compressible flows. In these problems, accurate geometric representation can be important, e.g., due to the presence of shock waves and their interaction with solid walls. Results are compared against solutions obtained with a standard finite element formulation.

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