Space-Time Computational Analysis: It Adds Another Dimension

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ABSTRACT

Space-Time (ST) Variational Multiscale (ST-VMS) method [1] and its predecessor ST-SUPS [2] have a good track record in computational analysis of complex fluid-structure interactions (FSI) and flows with moving boundaries and interfaces (MBI). The classes of challenging FSI and MBI problems with successful analysis range from spacecraft parachute FSI to wind-turbine aerodynamics, from flapping-wing aerodynamics of an actual locust to fluid mechanics of heart valves. When an FSI or MBI problem requires high-resolution representation of boundary layers near solid surfaces, ALE and ST methods, where the mesh moves to follow the fluid-solid interface, meet that requirement. Moving-mesh methods have been practical in more classes of complex FSI and MBI problems than commonly thought of. With a number of complementary methods introduced recently, the ST methods can now do even more. They can handle contact between solid surfaces or other topology changes, as enabled by the ST-TC method [3], or a spinning solid surface that is in contact with a solid surface, as enabled by the ST Slip Interface TC (ST-SI-TC) method [4]. Using NURBS as basis functions in space and time is further increasing the accuracy and scope of the ST methods [5]. The ST-SI method [6], which also provides mesh generation flexibility in a general context by accurately connecting nonmatching meshes, and a general-purpose NURBS mesh generation method introduced recently make spatial NURBS basis functions more practical in ST computations with complex geometries.

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