Space–Time Computation in FSI Analysis: It's Worth It

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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). 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 than that. They can deal with 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.

REFERENCES

[1] K. Takizawa and T.E. Tezduyar, "Multiscale space–time fluid–structure interaction techniques", *Computational Mechanics*, **48** (2011) 247–267, doi: 10.1007/s00466-011-0571-z.

[2] T.E. Tezduyar, "Computation of moving boundaries and interfaces and stabilization parameters", *International Journal for Numerical Methods in Fluids*, **43** (2003) 555–575, doi: 10.1002/fld.505.

[3] K. Takizawa, T.E. Tezduyar, A. Buscher, and S. Asada, "Space–time interface-tracking with topology change (ST-TC)", *Computational Mechanics*, **54** (2014) 955–971, doi: 10.1007/s00466-013-0935-7.

[4] K. Takizawa, T.E. Tezduyar, S. Asada, and T. Kuraishi, "Space–time method for flow computations with slip interfaces and topology changes (ST-SI-TC)", *Computers & Fluids*, **141** (2016) 124–134, doi: 10.1016/j.compfluid.2016.05.006.

[5] K. Takizawa, T.E. Tezduyar, Y. Otoguro, T. Terahara, T. Kuraishi, and H. Hattori, "Turbocharger flow computations with the Space–Time Isogeometric Analysis (ST-IGA)", *Computers & Fluids*, **142** (2017) 15–20, doi: 10.1016/j.compfluid.2016.02.021.

[6] K. Takizawa, T.E. Tezduyar, H. Mochizuki, H. Hattori, S. Mei, L. Pan, and K. Montel, "Space–time VMS method for flow computations with slip interfaces (ST-SI)", *Mathematical Models and Methods in Applied Sciences*, **25** (2015) 2377–2406, doi: 10.1142/S0218202515400126.