Multiscale Sequentially-Coupled FSI (SCFSI) Techniques

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The sequential-coupling techniques, which will be limited to certain classes of FSI problems, give us more computational efficiency and more flexibility. With that flexibility and a multiscale approach, we can increase the spatial and temporal accuracy of the solution in an efficient way. The multiscale sequentially-coupled FSI techniques we have developed are described in the context of the Stabilized Space-Time FSI (SSTFSI) technique [1]. In the spatially-multiscale SCFSI M1C technique [2], fluid mechanics meshes with different refinement levels are used at different stages of the SCFSI computation. With this approach, we reduce the FSI computational effort where we do not need it and increase the accuracy of the fluid mechanics computations where we need accurate, detailed flow computation. We first compute the structural deformation with the (fully) coupled FSI (CFSI) technique and a relatively coarse fluid mechanics mesh, followed by mesh motion and fluid mechanics computations with a more refined mesh. The spatially-multiscale SCFSI M2C technique [3] is multiscale for the structural mechanics part. We first compute the time-dependent flow field with the CFSI technique and a relatively coarse structural mechanics mesh, followed by a structural mechanics computation with a more refined mesh, with the time-dependent interface stresses coming from the previously carried out CFSI computation. With this technique, we can reduce the FSI computational effort where we do not need it and increase the accuracy of the structural mechanics computation where we need accurate, detailed structural mechanics computations, such as computing the structural stresses. We also propose the temporally-multiscale counterparts of these two techniques. The presentation will include test computations that show how the multiscale sequentially-coupled FSI techniques work.

