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SPACE–TIME COMPUTATIONAL FSI TECHNIQUES

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The presentation will focus on the core and special Space–Time (ST) FSI techniques introduced to bring solutions to some of the most challenging FSI problems, including spacecraft parachute FSI and flapping-wing aerodynamics of an actual locust. The ingredients of the core ST FSI technique include the ST interface-tracking (moving-mesh) method [1-3], appropriate stabilization parameters, robust mesh moving methods, temporal NURBS basis functions [4], and the variational multiscale (VMS) version of the ST formulation [2-3]. Special ST FSI techniques target the computational challenges involved in specific classes of problems. There will be two examples. A homogenization method [5, 6] is used for modeling the flow through hundreds of gaps and slits of spacecraft parachutes. This makes the problem tractable, with an accuracy that makes the comparison to test data very favorable. A temporal representation method with NURBS basis functions [4] is used for the motion and deformation of the locust wings, for the motion and deformation of the volume meshes computed, and in remeshing. This provides an accurate way of matching the data extracted from the high-speed, multi-camera video recordings of a locust in a wind tunnel, and a robust and efficient way of dealing with the mesh in computations that include near topology changes. The results presented from [4-7] for these two classes of problems (see, for example, Figures 1 and 2) show that the ST FSI techniques are helping with the design in applications as complex as spacecraft parachutes and enabling us to model the aerodynamics of structures as intricate and hard to represent as the flapping wings of an actual locust. The presentation will also include a brief description of the ST computation techniques with continuous representation in time (ST-C) [8], which use temporal NURBS basis functions. This gives us a temporally smooth, NURBS-based solution, which is desirable in some cases, and a more efficient way of dealing with the computed data.

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Figure 1. A cluster of three spacecraft parachutes with modified geometric porosity, at an instant during the FSI computation (see [6]).

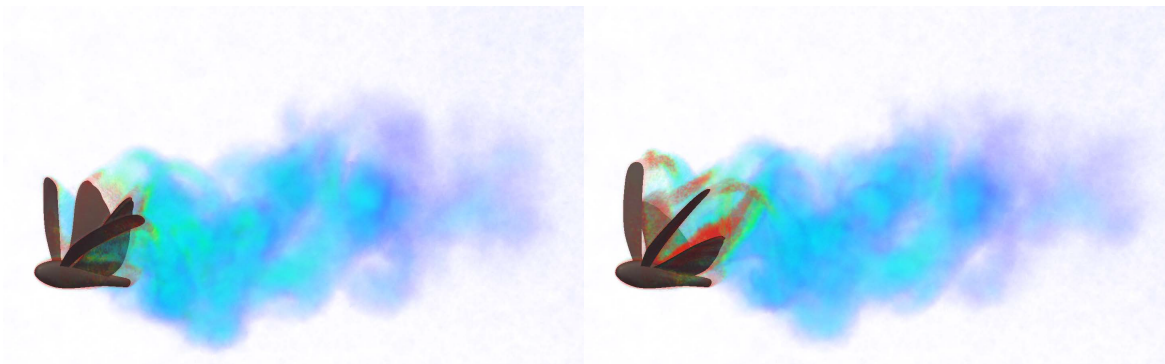

Figure 2. Vorticity at two instants during the flapping cycle in flapping-wing aerodynamics of an MAV, with the wing motion and deformation coming from an actual locust (see [7]).