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# ST-VMS COMPUTATIONAL ANALYSIS OF BIO-INSPIRED FLAPPING-WING AERODYNAMICS OF AN MAV

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We present computational analysis of bio-inspired flapping-wing aerodynamics of a micro aerial vehicle (MAV). The core computational technology is the space-time variational multiscale (ST-VMS) method [1,2]. This is the residual-based VMS version of the Deforming-Spatial-Domain/Stabilized ST (DSD/SST) method [3-5]. The computation is challenging because the motion of the wings is based on data extracted from video recordings of an actual locust in a wind tunnel (Figures 1 and 2). Furthermore, computing the correct aerodynamical forces acting on the wings requires a method that can, with a good level accuracy, resolve the flow field near the wing surfaces. The DSD/SST formulation is a moving-mesh technique, which enables us maintain the mesh resolution, and consequently the solution accuracy, near moving solid surfaces. A set of special ST techniques [6] is also used in the computations in conjunction with the ST-VMS method. The special techniques are based on using, in the ST flow computations, NURBS basis functions for the temporal representation of the motion of the wings and for the mesh moving and remeshing. The computational analysis [7] starts with the base case (Figure 3), and includes computations with increased temporal and spatial resolutions compared to the base case.

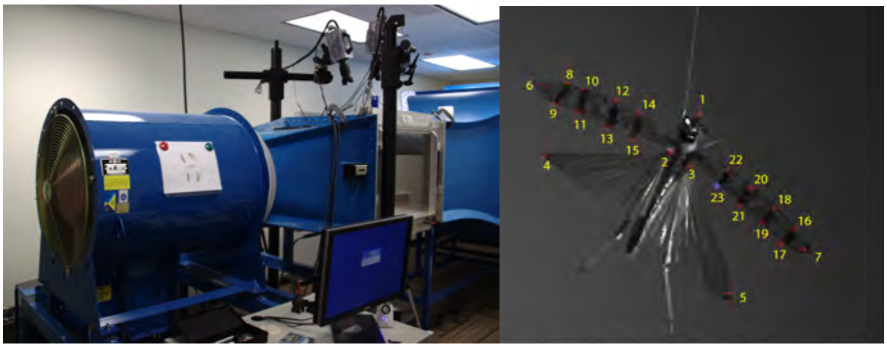

Figure 1. Wind tunnel at Baylor College of Medicine (BCM) with high-speed cameras and marked locust wings [6]. Picture from Drs. Fabrizio Gabbiani and Raymond Chan at BCM.

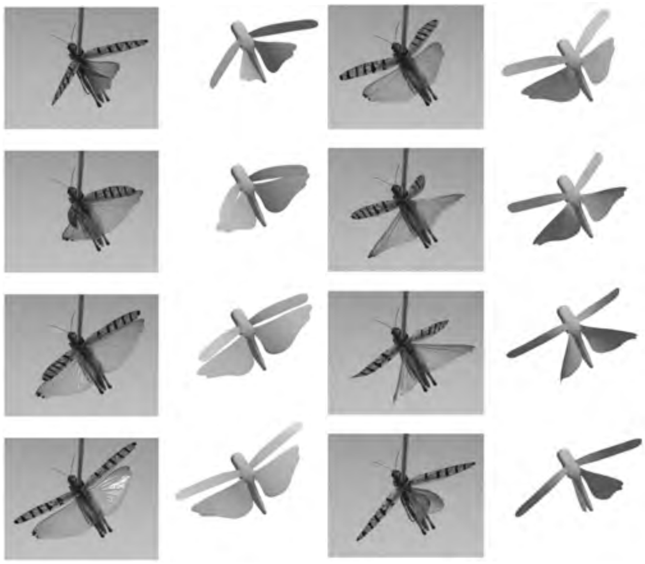

Figure 2. Computational model of the locust wings at different instants during the flapping cycle and wind-tunnel pictures [6].

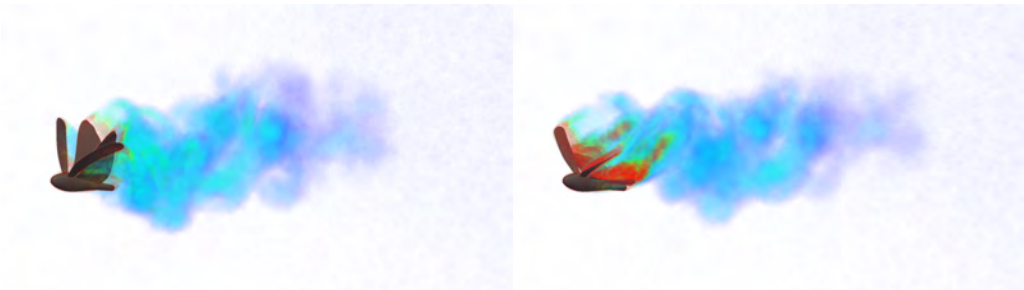

Figure 3. Vorticity around the MAV at different instants during the flapping cycle [7].

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