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Using adjoint-based optimization to study wing flexibility in flapping flight[1] MINGJUN WEI, MIN XU, New Mexico State University, HAIBO DONG, University of Virginia — In the study of flapping-wing flight of birds and insects, it is important to understand the impact of wing flexibility/deformation on aerodynamic performance. However, the large control space from the complexity of wing deformation and kinematics makes usual parametric study very difficult or sometimes impossible. Since the adjoint-based approach for sensitivity study and optimization strategy is a process with its cost independent of the number of input parameters, it becomes an attractive approach in our study. Traditionally, adjoint equation and sensitivity are derived in a fluid domain with fixed solid boundaries. Moving boundary is only allowed when its motion is not part of control effort. Otherwise, the derivation becomes either problematic or too complex to be feasible. Using non-cylindrical calculus to deal with boundary deformation solves this problem in a very simple and still mathematically rigorous manner. Thus, it allows to apply adjoint-based optimization in the study of flapping wing flexibility. We applied the "improved" adjoint-based method to study the flexibility of both two-dimensional and three-dimensional flapping wings, where the flapping trajectory and deformation are described by either model functions or real data from the flight of dragonflies.

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