Mechanical Engineering Department Seminar

3:35pm September 25, 2013
1130 Mechanical Engineering

To Understand Flapping-Wing Aerodynamics Through Adjoint-Based Optimization

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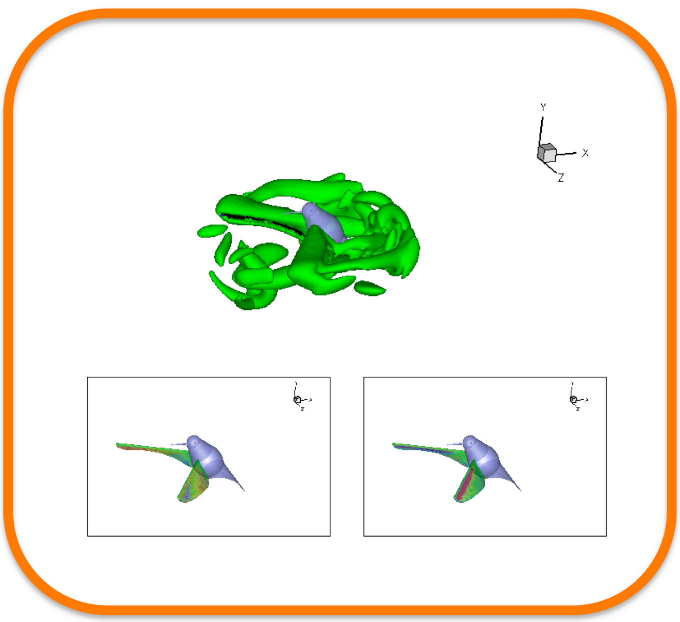
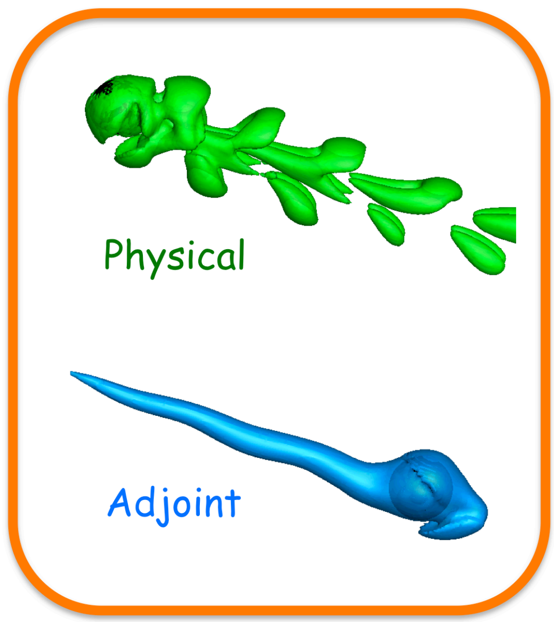
The study of flexible flapping wings of natural flyers and micro air vehicles remains challenging by the problem's unsteadiness, nonlinearity, moving boundary, and strong fluid-structure interaction. Here, we take a different route by driving directly to an optimal solution, which can, in return, provide a unique opportunity for understanding by its comparison to the initial or other performance status. With the large control space of the current problem, adjoint-based approach is a natural choice for its cost being independent of the number of control parameters. However, when unsteady flapping motion and deformation is considered, traditional adjoint-based approach used commonly in airfoil design falls short of even the definition of sensitivity at the moving/morphing boundary. Using unsteady mapping function could, in principle, be a remedy, but its formulation is often too complex to be feasible. Instead, we implement the idea of non-cylindrical shape analysis to derive an adjoint-based continuous approach in a rigorous and simple manner particularly for the optimization in moving boundary problems. At the end, the application of our approach to a pitching-plunging plate not only shows the algorithm efficiency but also reveals the mechanism behind the improvement of aerodynamic performance from some subtle changes.





Bio: Dr. Mingjun Wei is an Associate Professor of Mechanical and Aerospace Engineering Department at New Mexico State University. He received his PhD in Theoretical and Applied Mechanics from University of Illinois at Urbana-Champaign in 2004. After 2 years' postdoctoral work at Princeton University, he joined NMSU in 2006. Since then, his research has been supported by Army Research Laboratory (AHPCRC, MAST-CTA), Air Force Office of Scientific Research, and Sandia National Laboratories. His current research interests include: computational fluid dynamics, flow control and optimization, model order reduction, fluid-structure interaction, and computational aeroacoustics.