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CFD Modeling of Insect Flight at Low Reynolds Numbers

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Abstract : The typical insects employ a flapping-wing mode of flight. The numerical simulations on free flight of a model fruit fly (Re=143) including hovering and are presented in this paper. Unsteady aerodynamics around a flapping insect is studied by solving the three-dimensional Newtonian dynamics of the flyer coupled with Navier-Stokes equations. A hybrid-grid scheme (Generalized Finite Difference Method) that combines great geometry flexibility and accuracy of moving boundary definition is employed for obtaining flow dynamics. The results show good points of agreement and consistency with the outcomes and analyses of other researchers, which validate the computational model and demonstrate the feasibility of this computational approach on analyzing fluid phenomena in insect flight. The present modeling approach also offers a promising route of investigation that could complement as well as overcome some of the limitations of physical experiments in the study of free flight aerodynamics of insects. The results are potentially useful for the design of biomimetic flapping-wing flyers.

Keywords : free hovering flight, flapping wings, fruit fly, insect aerodynamics, leading edge vortex (LEV), computational fluid dynamics (CFD), Navier-Stokes equations (N-S), fluid structure interaction (FSI), generalized finite-difference method (GFD)
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