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Comparison of low and high fidelity models for the analysis of flapping wing micro air vehicles

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Millions of years of evolution have shaped and optimized the outstanding flight capabilities of natural flyers. Their high maneuverability, stable hovering and good adaptability to various wind conditions have inspired a new generation of drones known as flapping wing micro air vehicles. Those hand-sized drones could be valuable in demanding tasks such as rescues in confined environments but are currently far from replicating nature's full potential. A complete understanding and efficient modeling of flapping aerodynamics, characterized by highly unsteady flows at low Reynolds numbers, is still missing.

The present work defines two model types, a quasi-steady and an unsteady Computational Fluid Dynamics (CFD) model, and compares their aerodynamic predictions for flapping motions representative of the hovering regime. The quasi-steady model (QSM) relies on flapping aerodynamic fundamentals [1], quasi-steady assumptions and calibrated empirical constants [2]. The QSM can cheaply estimate the aerodynamic performance, as illustrated with the real-time optimization of two hovering scenarios. These results are then compared with a high fidelity CFD environment in OpenFOAM. Laminar simulations with the overset meshing technique allow to accurately reproduce the flow structures of different flapping strategies and analyze the flow physics deeply.

Finally, in light of the CFD simulations, the limits of the QSM are defined and promising CFD data-driven reduced-order models are discussed.

REFERENCES

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