PROPOSITION DE STAGE – MASTER 2

Titre : Optimization of flapping wing aerodynamics

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Durée / période : 6 mois

Candidature [CV, lettre de motivation, références] à envoyer à : thierry.jardin@isae.fr

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Sujet

The concept of flapping wings emerged in the early 1990's as a potential alternative solution to conventional rotating wings for the development of nano-air vehicles, i.e. extremely small size and light weight flying robots with dimensions ~1cm and mass ~100mg. This solution was inspired by insects which operate in the same, very low Reynolds number, flight regime. Yet, despite intensive research, it is still unclear whether or not flapping wings can outperform rotating wings in terms of aerodynamic performance and, accordingly, whether or not natural flyers have evolved towards optimal aerodynamic solutions. This is partly due to the difficulty in exploring the very large parameter space characterizing flapping wings, and hence uncover efficient flapping wing kinematics.

In this project, we propose to use multi-fidelity optimization to evaluate optimal flapping wing kinematics and answer the above questions. This work will rely on direct numerical simulations of a flapping wing, conducted at different levels of spatial and temporal resolution, coupled with appropriate optimization procedures (e.g. artificial intelligence). Parameters like flapping amplitude, angle-of-attack and phase delays will be explored. High-fidelity computations will then be performed on optimal kinematics (see figure) and the flow physics will be analyzed to provide insight into the prominent mechanisms reponsible for high aerodynamic efficiency.

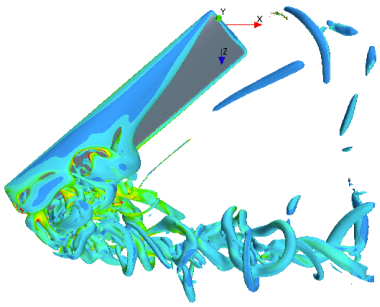

figure : vortices around a flapping wing

Students looking for a final master thesis internship are welcome to apply. Skills in numerical simulations and fluid mechanics/vortex dynamics/aerodynamics will be greatly appreciated. Knowledge in the following softwares/languages will be a plus : StarCCM+, Latex, matlab, python

References :

- Jardin, T., Farcy, A., & David, L. (2012). Three-dimensional effects in hovering flapping flight. Journal of fluid mechanics, 702, 102-125.
- Jardin, T., David, L., & Farcy, A. (2010). Characterization of vortical structures and loads based on time-resolved PIV for asymmetric hovering flapping flight. In Animal Locomotion (pp. 285-295). Springer, Berlin, Heidelberg.