Wing flutter control using artificial intelligence

Department: Department of Aerodynamics, Energetics and Propulsion (DAEP)

JOB DESCRIPTION:

Light aircraft with high aspect ratio wings typically suffer from wing flutter, an aeroelastic phenomenon that limits their flight speed. More specifically, above a critical flight speed, an aeroelastic instability arises that leads to the oscillation of the wing as a response to aerodynamic loads. In the worst case scenario, the wing can break under such structural stresses. The aim of the internship is to assess whether an active control of the wing flap, through artificial intelligence, can help mitigate this phenomenon.

The active control will rely on Reinforcement Learning (RL), an approach that seeks an optimal controller without prior modelization of the physics or knowledge of the physical mechanisms at play [1]. That is, the optimal controller is learned through a trial and error process where the RL algorithm constantly interacts with the environment (i.e. the system that we want to control, in this case the deformable wing in an airflow). In the first part of the internship, the candidate will apply RL to a simple 2D aeroelastic model based on unsteady thin airfoil theory (Wagner's theory) and the equations of motion for pitch and plunge. On the contrary to most 2D aeroelastic models of wing flutter, the present model will be derived in the time domain to allow for real time control using RL. Here, the candidate will seek to understand the role of measurement noise and actuation frequency on the optimal control in view of the second part of the internship.

In the second part of the internship, the candidate will apply RL to a wind tunnel experiment. This challenging task requires to connect the RL framework (developped in the previous part) to hardware devices in experiments. This raises many practical questions related to the role of measurement noise and acquisition/actuation frequency on the optimal control, for example. As opposed to the theoretical framework derived in the previous part, measurement noise and acquisition/actuation frequency are here imposed by `real life' conditions (i.e. they are inherent to wind tunnel tests). In addition, other more fundamental questions will be addressed, related for example to transfer learning, i.e. in that case the ability to develop an optimal control based on both theoretical models and experiments.

The internship will be conducted at the Department of Aerodynamics, Energetics and Propulsion (DAEP), in collaboration with the Department of Mechanics, Structures and Materials (DMSM), at ISAE-SUPAERO in Toulouse. It is part of a larger project where numerical simulations (Computational Fluid Dynamics, CFD) will be conducted on the same setup. It will be followed by a PhD thesis on the same topic.

REQUIRED PROFILE:

DAEP and DMSM are looking for a candidate (Master level) with a strong background in one or more of the following topics : aerodynamics, structural dynamics and control. Knowledge in Artificial Intelligence and Reinforcement Learning is a plus. The candidate should have particular interest in experiments. Applications should be sent to thierry.jardin@isae.fr (CV and previous internship reports if relevant).

DURATION: 5-6 MOIS

LOCATION: ISAE-SUPAERO, Toulouse

RESPONSIBLE OF THE SUBJECT:

Michael Bauerheim, professeur associé, ISAE-SUPAERO, michael.bauerheim@isae.fr
Thierry Jardin, directeur de recherche, ISAE-SUPAERO, thierry.jardin@isae.fr

APPLICATION PROCESS:

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

REFERENCES:

[1] Berger, S., Ramo, A. A., Guillet, V., Lahire, T., Martin, B., Jardin, T., Rachelson, E. & Bauerheim, M. (2024). Reliability assessment of off-policy deep reinforcement learning: A benchmark for aerodynamics. Data-Centric Engineering, 5, e2.