Cenaero

Réf.BE-IP-2024-002

INTERNSHIP PROPOSAL

Aerodynamical optimization of a 3D wing subject to mechanical constraints

Cenaero, located in Gosselies (Belgium), is a private non-profit applied research center providing to companies involved in a technology innovation process numerical simulation methods and tools to invent and design more competitive products. Internationally recognized, in particular through its research partnership with Safran, Cenaero is mainly active in the aerospace (with an emphasis on turbomachinery), process engineering, energy and building sectors.

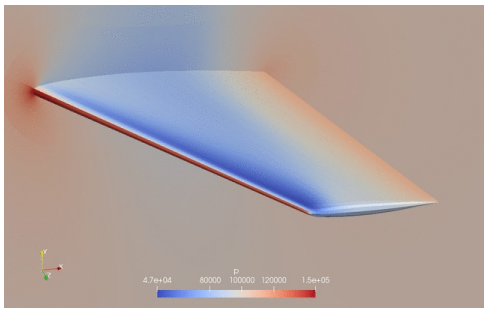
Cenaero provides expertise and engineering services in multidisciplinary simulation, design and optimization in the fields of mechanics (fluid, structure, thermal and acoustics), manufacturing of metallic and composite structures as well as in analysis of in-service behavior of complex systems and life prediction. Cenaero also provides software through its massively parallel multi-physics platform Argo, its manufacturing process simulation and crack propagation platform Morfeo and its design space exploration and optimization platform Minamo.

Cenaero operates the Tier-1 Walloon supercomputing infrastructure with 14,000 computing cores (see tier1.cenaero.be for details).

Within Cenaero, the Machine Learning and Optimization theme is dedicated to the development of algorithms and methods to address complex industrial design cases, with several achievements in aeronautics in particular [1-2].

Context

The aeronautical sector faces huge challenges in order to be both **environmentally friendly** and **economically profitable**. In this context, great efforts are pursued to make the best use of the materials manufactured to build airplanes. For example, by minimizing the weight of the wing and fuselage structures, the kerosene consumption of aircraft engines can be significantly diminished, thereby reducing the CO_2 emissions. Fortunately, in order to widely (and smartly) explore potentially better designs, **advanced machine learning and optimization algorithms** are constantly developed and coupled with high-level numerical **aerostructural and aerodynamical simulations**, and have proved their efficiency to find innovative solutions.



Practically, a demonstrator of the **Onera M6 wing** has been developed to assess its aerodynamical behavior. This demonstrator contains a parametric tool based on Free Form Deformation (FFD) to generate a wide range of 3D wing geometries. Furthermore, it interacts with Computational Fluid Dynamics (CFD) open-source codes (OpenFOAM / DAFoam) to calculate the pressure fields, velocities, etc. The global simulation chain handling the parametrization and simulation phases has been written in Python [3], and integrates a post-processing tool to calculate the lift-to-drag ratio and extract plots of the physical fields of interest.

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Objective

Based on the Onera M6 demonstrator developed at Cenaero, the goal of the internship is to perform the design optimization of the wing geometry with Minamo (Cenaero in-house code), and compare it with state-of-the-art solutions (both from the literature and with other optimization algorithms). The internship will consist in three steps:

1. **Work Package 1 – Discovery**:
   - perform a state-of-the-art on aerodynamical / aeromechanical wing design optimization;
   - get yourself familiar with the existing demonstrator;
2. **Work Package 2 – Implementation**: based on the existing demonstrator, program in Python the following improvements:
   - incorporation of mechanical constraints to ensure the structural integrity of the wing;
   - couple the simulation chain with Minamo software;
   - couple the simulation chain with state-of-the-art optimization algorithms (e.g., COBYLA);
3. **Work Package 3 – Analysis**: detailed post-processing and critical analysis of the results obtained.

The outcome of the internship is thus to contribute to the comparison of optimization algorithms for wing design, on a realistic benchmark case.

Profile

- Required: Bachelor + ongoing Master's studies in Mechanical, Electromechanical, or Aeronautical Engineering.
- Languages: English and/or French.
- Pre-requisites: notions of aerodynamics and/or structural mechanics + programming (Python).
- Motivation, creativity and team spirit!

Duration

The length of the internship can vary from 3 months to 6 months, depending on your university or school regulations.

Contact

If you are interested by this topic, please send a cover letter, quoting the reference number of the offer, as well as your resume, to rh_be-ip-2024-002@cenaero.be

References

[1] Baert, L., Chérière, E., Sainvitu, C., Lepot, I., Nouvellon, A., Leonardon, V. *Aerodynamic Optimisation of the Low Pressure Turbine Module: Exploiting Surrogate Models in a High-Dimensional Design Space*. Journal of Turbomachinery. 142:1-24 (2020).
[2] Beaucaire, P., Beauthier, C., Sainvitu, C. *Multi-point infill sampling strategies exploiting multiple surrogate models*. GECCO '19: Proceedings of the Genetic and Evolutionary Computation Conference Companion, pp. 1559-1567 (2019).
[3] Caudron, J., *Aerostructural optimization of an aircraft wing assisted by dimensionality reduction methods.* Master's Thesis, Université de Liège (2024).