Cenaero

Ref.: BE-IP-2025-004

# INTERNSHIP PROPOSAL

# Benchmarking of optimizers

Cenaero, located in Gosselies (Belgium), is a private non-profit applied research center providing companies involved in a technology innovation process with 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 Lucia with 4 Pflops peak performance and was ranked 245th on the November 2022 Top500 List (see tier1.cenaero.be for details).

Within Cenaero, the Machine Learning and Optimization group is dedicated to the development of algorithms and methods to address complex industrial design cases, with several achievements in aeronautics in particular [1-2]. It incorporates the Minamo team, dedicated to the development of Cenaero's in-house multi-disciplinary optimization platform. Although computing power has increased dramatically in the last decades, computational burden is still an issue as more and more complex simulation analyses are required in industrial design processes. Aiming to tackle this numerical challenge, Minamo provides efficient online Surrogate-Based Optimization (SBO) methods, based on evolutionary algorithms, allowing to quickly gain insight into the design space, to quantitatively identify key factors and trends and to automatically find innovative design options. It implements several variants of mono- and multi-objective evolutionary strategies, efficiently coupled in an online framework (i.e with continuous enrichment of the construction support along the design iterates) to surrogate models.

## Context

A classical SBO approach consists of several major components, as shown in Figure 1. The first step relates to the Design of Experiments (DoE) which provides data for the initial surrogate model training. The second step consists in the training of the surrogate model(s). The third aspect of such optimization techniques is the choice of the model updating strategy. The last step is the evaluation of the stopping criterion to determine whether a new iterate is needed or not. The objective of the proposed research work is to benchmark different optimization techniques in comparison with the native Evolutionary Algorithm (EA) implemented in Minamo. Different optimization strategies, already accessible in some open-source packages (for instance: pymoo, scipy, Dakota, NLOPT) can be benchmarked.

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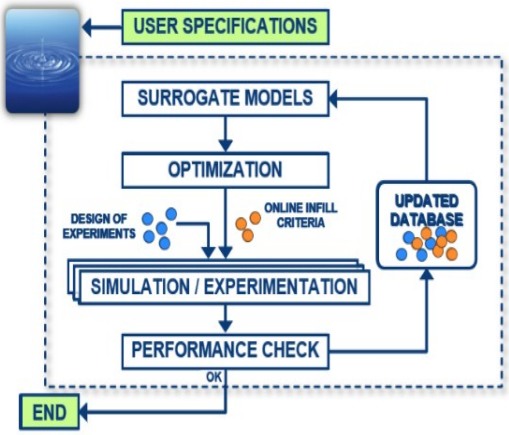


Figure 1: Online SBO scheme

## Objective

The aim of this work is to:

- Select the optimization strategies to be benchmarked and their associated external implementation
- Plug the selected packages in Minamo's modularity framework
- Perform a benchmark of these strategies and validate on different mathematical problems

Depending on the progress and results obtained during this internship, these strategies may be tested on a realistic benchmark related to wing design.

The candidate will join the Machine Learning & Optimization group.

## Profile

- Required: Master's student in Mathematics, Engineering or Computer Science.
- Languages: English and/or French.
- Prerequisites: Good programming skills as well as good mathematical background. Working knowledge of Linux and Python are valuable assets.
- 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-2025-004@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).