Cenaero

Ref.: BE-IP-2026-03

INTERNSHIP PROPOSAL

Towards Data-Efficient Machine Learning for Aerodynamic Modeling via Transfer Learning

Cenaero, located in Gosselies (Belgium), is a private, non-profit applied research center that supports companies involved in technological innovation by providing advanced numerical simulation methods and tools to design and develop more competitive products. Internationally recognized, Cenaero operates mainly in the fields of aeronautical design, space systems, manufacturing processes, as well as smart buildings and cities.

Cenaero provides engineering expertise and services in high-performance composites, optimization and uncertainty quantification, multidisciplinary topology optimization, metal manufacturing process modeling, high-resolution computational fluid dynamics, hypersonic flows and ablative materials, thermo-fluid processes and system modeling, turbomachinery design, high-performance computing and machine learning.

In addition, Cenaero develops software through its massively parallel multiphysics platform Argo, its manufacturing process and crack-propagation simulation platform Morfeo, and its design-space exploration and optimization platform Minamo.

Cenaero operates the Tier-1 Walloon supercomputing infrastructure with combined (CPU + GPU partitions) peak performance about 4 PetaFLOPS, that was ranked 245th on the November 2022 Top500 List with its GPU partition (see tier1.cenaero.be for details).

Context

The aeronautical industry faces enormous challenges in ensuring that it is both environmentally friendly and economically viable. To achieve these goals, significant efforts are undertaken to make the best possible use of the materials and equipments in the aircraft. For example, by minimizing the weight of the wing and fuselage structures, the kerosene consumption of aircraft engines can be considerably reduced, thereby limiting CO_2 emissions. Fortunately, to widely and smartly explore potentially better designs, advanced machine learning and optimization algorithms are constantly being developed and coupled with high-level aerostructural and aerodynamic numerical simulations; such strategies have proved their effectiveness in finding innovative solutions.

However, the development, quality, and performance of advanced machine learning models strongly depend on the quantity and quality of the available data. The number of available training samples directly affects prediction accuracy, and the amount of data required to reach task-specific performance remains a major limitation for their industrial deployment . This issue is particularly critical in scientific machine learning (SciML), and especially in fluid dynamics, where training data are typically obtained from expensive numerical simulations or experimental campaigns.

The objective of this work is to investigate strategies for reducing the amount of data required to train accurate deep learning models for aerodynamic prediction. Building on existing databases, models, and simulation workflows, the project aims to bridge the gap between traditional design-of-experiments datasets and modern foundation-model approaches in scientific machine learning (SciML) by leveraging transfer learning methods.

The internship will focus on the well-known 3D wing configuration of the ONERA M6 demonstrator. The aim is to develop a deep learning model that can predict wall pressure and shear stress for different operating conditions and geometry modifications. First, the model will be trained on a dataset specifically created for this configuration using design-of-experiments methods, covering a range of geometries and operating conditions. Second, the same model will be trained on a larger external dataset available online that includes various wing designs and operating conditions, which are not identical to the ONERA M6 but involve similar physical phenomena. Finally, a hybrid approach will be tested, where a model pre-trained on the large external dataset is fine-tuned using only part of the specialized dataset through transfer learning strategies.

Comparing these different strategies, particularly in terms of the amount of data required to achieve a target level of predictive accuracy, will provide insight into the effectiveness of transfer learning strategies. Ultimately, the study aims to demonstrate how such approaches can reduce data requirements while maintaining high predictive performance in scientific and engineering machine learning applications.

Objectives

The primary objective of the internship is to develop a deep learning model trained on multiple datasets in order to investigate transfer learning strategies for aerodynamic prediction. The work will be structured into three main work packages.

Work Package 1 – Baseline model and dedicated dataset

- Develop and train a deep learning model to predict wall pressure and wall shear stress on the ONERA M6 wing using a dataset specifically generated for this configuration

Work Package 2 – Training with an external dataset

- Retrain the same model using a larger, freely available external dataset containing similar, yet not identical, wing geometries and operating conditions, in order to assess its ability to generalize from diverse data .

Work Package 3 – Transfer learning and specialization

- Develop a third model that is first pre-trained on the external dataset and then fine-tuned using a subset of the original dedicated dataset, to evaluate the benefits of transfer learning for reducing data requirements.

Profile

- ***Required: Bachelor + ongoing Master's studies in Mechanical, Electromechanical, or Aeronautical Engineering or data science or applied Mathematics.***
  The position is suitable for either:
  - ***a student in aerospace or mechanical engineering with a strong interest in machine learning, or***
  - ***a computer science student with a strong interest in engineering and fluid mechanics.***
- *Languages: English and/or French.*
- *Pre-requisites: programming (Python).*
- *Plus : notions of aerodynamics and/or structural mechanics and/or deep learning are appreciated*
- *Motivation, creativity and team spirit!*

Duration

The length of the internship can vary from 4 months to 6 months, depending on your university or school regulations.

Contact

Interested candidates should send a cover letter, quoting reference number of the offer (BE-IP-2026-03) and a resume to rh_be-ip-2026-03@cenaero.be