

PHD THESIS PROPOSAL

Title: Multi-fidelity adaptive design of experiments and surrogate models for data fusion in aerodynamics

Reference: **TIS-DTIS-2023-Number of the order**
(to be mentioned in all correspondence)

Starting date: October 2023

Deadline: May 2023

Keywords

Surrogate model, aerodynamics, wind-tunnel testing, uncertainty propagation, design of experiments

Profile and skills required

Knowledge in applied mathematics and aerospace sciences, Python programming

Presentation of the PhD subject, context and objective

During the aircraft design process, it is necessary to use both numerical simulations and wind tunnel tests to validate the different performances of the aircraft. These two means of prediction produce complementary data in terms of accuracy, information density and cost.

The proposed PhD thesis seeks to tackle this problem and supports the first joint work between a scientific department and the wind tunnel department of ONERA. It aims at proposing a method to assemble these complementary data in order to use them in an optimal way, especially considering their respective uncertainties, and with an active learning focus, for instance the enrichment of the databases in areas of interest.

The research tasks that will be covered by the PhD student are the following.

- In conjunction with the wind tunnel department, to contribute to the identification of important parameters to characterize both the test databases and the numerical simulations (structure of the data and their associated uncertainties).
- To apply state-of-the-art surrogate model techniques to available hybrid databases (experimental and simulation) and to identify their shortcomings.
- To adapt and extend the capabilities of these techniques (especially, Kriging/Gaussian processes) to cope with the specificities of experimental data (large number of points, inadequate space coverage, variable uncertainty, hysteresis, etc.).
- To develop a dynamic sampling technique adapted to the constraints of the experimental activity and able to produce an optimal test program and to propose enrichment points during the experiment.

This PhD thesis will extend the state of the art in design of experiments and surrogate models in order to apply these techniques to aerodynamic data, in particular to experimental data from wind tunnels.

The PhD student will be hosted in the M2CI team located in Toulouse (France) and will be able to visit the wind tunnels of Fauga Mauzac (France). He/she will benefit from existing experimental and numerical databases. These databases are based on NASA's Common Research Model. They have been produced at ONERA using world-class wind tunnels and simulation software. The PhD student will contribute to the development of the SMT toolbox dedicated to surrogate models, in Python, jointly developed by NASA, the University of Michigan, ISAE-SUPAERO and ONERA.

The PhD student will be co-supervised by the ONERA and the Université Polytechnique Hauts-de-France (UPHF, Valenciennes). A further collaboration is expected with the Institut für Aerodynamik und Strömungstechnik (BRAUNSCHWEIG) of the DLR in Germany on dynamic sampling techniques.

REFERENCES:

DeLoach, R. (2006, January). The modern design of experiments for configuration aerodynamics: a case study. In *44th AIAA Aerospace Sciences Meeting and Exhibit* (p. 923).

Arenzana, R. C., López-Lopera, A. F., Mouton, S., Bartoli, N., & Lefebvre, T. (2021, July). *Multi-fidelity Gaussian process model for CFD and wind tunnel data fusion*. In AeroBest 2021.

Nigam, N., Mohseni, S., Valverde, J., Voronin, S., Mukhopadhaya, J., & Alonso, J. J. (2021). *A Toolset For Creation of Multi-Fidelity Probabilistic Aerodynamic Databases*. In AIAA Scitech 2021 Forum (p. 0466).

Bertram, A., & Zimmermann, R. (2018). *Theoretical investigations of the new Cokriging method for variable-fidelity surrogate modeling*. Advances in Computational Mathematics, 44(6), 1693-1716.

J. Slotnick et al., CFD Vision 2030 Study: A Path to Revolutionary Computational Aerosciences, NASA/CR-2014-218178, 2014

Expected collaborations

- Université Polytechnique Hauts-de-France (UPHF, Valenciennes) for the co-supervision of the PhD thesis
- DLR-Braunschweig (mobility of a few months possible)

Host laboratory at l'ONERA

Department: Information processing and systems (DTIS)

Location (ONERA research center): Toulouse (France)

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