Stage Master Recherche - Master Research Internship

Title: Implementation of an efficient Kalman Smoother for applications in turbomachines

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Keywords: CFD; Data Assimilation

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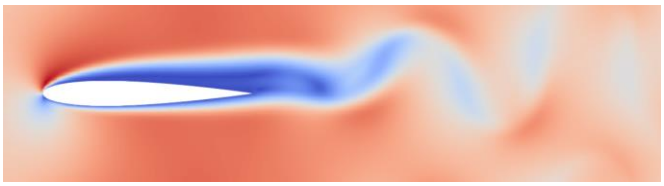
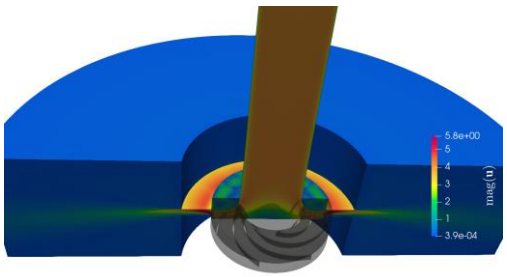
Location: LMFL, ENSAM, 8 Bd Louis XIV, 59000 Lille
Duration & start date: 6 month beginning spring 2026, accordingly to the availability of the candidate
Expected skills and knowledge: competences in numerical simulation, statistics are welcome
Additional points: this internship is followed by a PhD

Level : **M2**





Subject: The analysis of turbulent flows is a critical component for achieving energy efficiency and reducing the carbon footprint in industrial applications. The projects ANR JCJC IWP-IBM-DA (2021-2026) and ANR PRC MALEAF (2025-2029) are specifically dedicated to developing advanced computational tools to improve energy efficiency, particularly in rotating machines. This class of flow is fundamental to numerous sectors, including aerospace engineering, wind/water farms, and medical applications. Flows around rotating machines are traditionally studied through physical experiments and Computational Fluid Dynamics (CFD). While CFD offers the advantage of representing the entire physical domain and providing a more complete flow map, its accuracy can be limited by modeling and boundary condition errors. This project addresses this limitation by using Data Assimilation (DA) [1,2] techniques to **fuse data from both experiments and CFD**. This approach leverages the high accuracy of experimental data and the comprehensive domain coverage of numerical simulations to yield more reliable results.

Objectives: The primary goal of this internship is to optimize an **Ensemble Kalman Smoother** (EnKS) procedure. The EnKS is a Data Assimilation technique that exhibits promising features for the analysis of complex, industrial-scale turbulent flows. The research will utilize the **CONES platform**, which has been specifically developed at the Host laboratory [3,4]. The numerical simulations will be performed using the CFD library OpenFOAM.

Key Tasks:

- Initial Study: The developed technique will first be studied using two-dimensional configurations (e.g., a NACA profile).
- Expansion: A rapid progression of the work may allow for an application to three-dimensional cases.

- Sensitivity Analysis: A thorough investigation will be conducted on the sensitivity of various numerical ingredients and hyperparameters, assessing their impact on simulation accuracy. This includes i) CFD Parameters: Grid refinement and turbulence modeling and ii) EnKS Hyperparameters, localization and inflation.

💡 **Important Opportunity (PhD Track)**
This internship is designed to lead directly into a PhD position. The selected candidate will gain a significant technical advantage over external applicants during the subsequent PhD selection interviews due to their familiarity with the project, tools, and research objectives.

Bibliography

[1] G. Evensen, Sequential data assimilation with a nonlinear quasi-geostrophic model using Monte Carlo methods to forecast error statistics, Journal of Geophysical Research 99: 10143 (1994).
[2] M. Asch, M. Bocquet, M. Nodet, Data Assimilation: methods, algorithms, and applications, SIAM, (2016).
[3] L. Villanueva, M. Valero, A. Sarkic Glumac, M. Meldi, Augmented state estimation of urban settings using on-the-fly sequential data assimilation, Computers & Fluids 269: 106118 (2024).
[4]https://cones-dev-pe431-2dbff22738a4d54c2b947e6fa9a9a77fadd187b3bd1a85c.gitlab-pages.ensam.eu/