Post-doctoral position at IFP Energies nouvelles (IFPEN)
in *Applied mathematics and/or Mechanical engineering (Fluid mechanics and Energetic)*

Augmented LES using Data assimilation: Application to unsteady compressible and incompressible flows

Mots clés : Data Assimilation (DA), Ensemble Kalman Filter (EnKF), CFD, Large-Eddy Simulations (LES)

Data assimilation is a powerful technique that addresses several challenges in the field of Computational Fluid Dynamics (CFD). One of the main challenges is to reduce uncertainties related to initial conditions and model parameters, which can significantly affect the instantaneous evolution of the flow and lead to a loss of synchronization with reference measurements. This is where data assimilation comes into play, particularly with the use of the Ensemble Kalman Filter (EnKF), as developed in the framework of the ANR Alekcia project by the Pprime partner.

The main interest of this method is twofold. Firstly, it allows the optimization of uncertain parameters, such as boundary conditions and subgrid models for LES (Large Eddy Simulation). Unlike UQ (Uncertainty Quantification) approaches where optimization is performed a posteriori, optimization with data assimilation is done on-the-fly during calculations. Secondly, it corrects the velocity and scalar fields to match experimental observations, thereby increasing the accuracy of numerical simulation predictions.

The method developed in Alekcia is semi-intrusive, meaning that the algorithm is coded outside the CFD solver but still requires coupling with the solver to modify on-the-fly the parameters to be optimized and the fields to be assimilated regardless of the number of cores (parallel computations). This work has been successfully applied at Pprime to an incompressible flow around an obstacle, representing an atmospheric flow around a building. The results show a notable improvement in the prediction of velocity fields thanks to data assimilation. The CFD solver used is OpenFoam, known for its flexibility and wide range of applications in fluid dynamics. Work is ongoing with initial results to extend the technique to an unsteady compressible flow.

The objective of the post-doc is to achieve the coupling of the EnKF algorithm (which is a common result of the Alekcia project) with a CFD code widely used in the team, to perform unsteady compressible simulations. We will take advantage of the experimental database generated by Prisme, within the framework of the Alekcia project, on a hydrogen-powered engine configuration to evaluate the implementation and analyse the results. In particular, the study will aim to reproduce specific individual engine cycles.

Subsequently, the coupling can be done with LBM-based solvers to study atmospheric flows. Data assimilation combined with concentration measurements carried out in the FLAIR project will also improve the prediction of pollutant dispersion and trace back to the source. This innovative integration of advanced simulation methods and experimental measurements aims to provide robust predictive tools for various industrial applications, ranging from engine aerodynamics to urban air quality management.

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Post-doctoral location	IFP Energies nouvelles, Rueil-Malmaison, France
Duration and start date	12 months with possible 6 months extension, **as soon as possible**
Employer	IFP Energies nouvelles, Rueil-Malmaison, France
Salary	3400 € Gross/month + bonus for international mobility
Academic requirements	PhD in Applied mathematics and/or Fluid mechanics and/or Energetic
Language requirements	Fluency in French or English, willingness to learn French
Other requirements	Data Assimilation using sequential approaches, numerical simulation of turbulent flows, programming (Python and C++)

For more information or to submit an application, contact the IFPEN supervisors.

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