PhD position

Image assimilation in large eddy models with uncertainty: application to 3D turbulent flows reconstruction

General description

We offer a three-year PhD position within the joint INRIA/Cemagref research group FLUMINANCE, located in Rennes, France. This research concerns the study of methods for the estimation and analysis of fluid flow from image sequences. More particularly, the PhD student will investigate new mathematical tools to reconstruct 3D turbulent flows from multi-planes image acquisition by coupling image sequences with large eddy simulations (please find below a detailed description of the subject).

Environment

During her/his PhD thesis, the researcher will be considered as a full member of the FLUMINANCE team. FLUMINANCE is a joint research team between INRIA and Cemagref. INRIA is one of the leading research institutes in Applied Mathematics and Computer Sciences in France and Cemagref is a French major research institute in environmental science and technologies. The FLUMINANCE research group is composed of 5 full-time researchers, 5 PhD students and 3 post-doctoral fellows. Its main research activities focus on the study of turbulent flows from image data sequences. The team is part of numerous industrial and academic projects. In particular, it is currently involved in several national collaborations with Ifremer and Meteo France.

We refer the applicant to the team's website for more information:
http://www.irisa.fr/fluminance/indexFluminance.html

Skills and profile

The candidate must have a solid background in applied mathematics and/or fluid mechanics. He must have a good knowledge in programming languages. Good skills in fortran is an asset.

Contact

Applicants must send their candidature (resume, letter of motivation and letters of recommendation) to

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Detailed subject

Fluid flows involved in environmental sciences (meteorology, oceanography, water cycle) or in engineering applications are three-dimensional and turbulent. Our ability to measure or to simulate them is still limited. Even with the highest available capacities in term of sensors sensitivity, spatiotemporal measurement resolution, grid refinement and computational power, there will always remain a lack of resolution and some missing input about actual limit conditions. Yet, we have Navier-Stokes equations and image sequences containing actual dynamic of the concerned problem. If better simulations and measurements are possible, something useful may be learnt from data assimilation techniques.

Data assimilation consists in coupling and mixing experimental and simulated data at compatible spatiotemporal scales. The inclusion of dynamical models as constraints of the data analysis process brings a guarantee of coherency based on fundamental equations known to correctly represent the dynamics of the flow. Conversely, the injection of experimental data into simulations ensures some fitting of the model with reality. When used with the correct level of expertise to calibrate the models at the relevant scales this collaboration represents a powerful tool to analyze and reconstruct turbulent flows.

Image sequences represent an important source of information since they characterize dynamics on a large range of scales in comparison to sparse information contained in "in situ" data. Moreover, the volume of remote sensing image sequences has drastically increases these last years. However, image data can provide dense vector field information only in a plane, or recently sparse vector field information in a volume. Three dimensional vector field information of complex flow configurations can be obtained with large eddy simulation (LES). The technique resolves large scales of the 3D flow field solution and models the smallest scales of the solution, rather than resolving them. This makes LES a powerful tool for engineers to analyze turbulent flows.

This PhD is motivated by the need of tools for reconstructing 3D turbulent flows. The PhD candidate will investigate the use of data assimilation techniques for the coupling of large eddy simulations (LES) and 2D image data providing dense information [1,2]. The goal is to reconstruct a 3D flow from a set of 2D plane image sequences (e.g. 2 or 3 planes perpendicular or parallel) and a large eddy model of the turbulence. Image data can in principle enable the adjustment and the choice of the most relevant parameters of the dynamics [3]. Instead of predefining small scales models, one of the goals of this PhD will consist in estimating parameters values from the data. Along term goal would be to learn empirical small scales models directly from image data.

This PhD will take place in the context of the FLUMINANCE team of the research centers of INRIA and Cemagref Rennes (France). Close collaborations are expected with national and international (UBA Argentina) academic partners.

Keywords: Turbulence, data assimilation, large eddy simulation, optical flow, PIV

References

[1] N. Papadakis, E. Mémin. Variational assimilation of fluid motion from image sequences. SIAM Journal on Imaging Science, 1(4):343-363, 2008.

[2] A. Gronskis, D. Heitz, E. Mémin. Inflow and initial conditions for direct numerical simulation based on adjoint data assimilation. In TSFP-7, Ottawa, Canada, July 2011.

[3] M. Bocquet. Towards optimal choices of control space representation for geophysical data assimilation. *Monthly Weather Review*, 137(7):2331-2348, July 2009.

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