PhD position starting in 2018 at Irstea, Rennes, France

Development of an advanced 3D flows measurement technique

Short PhD project description

This project aims at developping a novel measurement technique to numerically reconstruct large volumes of real world experiments. The goal is to devise new experimental and numerical technologies to reconstruct in a dense and spatiotemporal consistent way large-scale and time resolved velocity volumes.

Our daily life is surrounded -and often sustained- by the flow of fluids. Blood moves through our arteries and air flows into our lungs. Fluid flows disperse particulate air pollution in the turbulent urban as well as indoor environments. Fluid flows play a crucial role for our transportations and our industries. Our vehicles move through air and water powered by still other fluids that mix in the combustion chambers of engines. *Many of the environmental and energy-related issues we face today cannot possibly be tackled without a better understanding of the dynamics of fluids*. From a practical point of view, fluid flows relevant to the scientists or to the engineers occur in the turbulent regime, the rule rather than the exception. To date, a complete theory of fluid flow phenomena is still missing because of the complexity of the full equations describing the motion of a fluid and of the limitations of measurements tools.

In all the above-mentioned domains, realistic numerical flow simulations resolving the entire hydrodynamics scales – ranging from the forcing scale up to the dissipation scale – are far beyond the reach of computers. For complex flows only large-scale models can be handled. This modelling constraint is even tighter when real time is required for flow control applications for example. Due to such a limitation, joint analysis coupling experimental and numerical studies are inescapable. To validate the models, the experimental analyses are typically based on optical measurements, carried out on flows reproduced through laboratory facilities (hydraulic veins or wind tunnels). *The common ultimate goal of these approaches is to provide a three-dimensional representation of the flow and its dynamic in order to better understand and model the underlying physical phenomenona*.

Despite being complementary, experimental and numerical approaches are facing strong limitations for the study of complex scenarios. In three dimensions, despite recent progress (Scarano *et al.* 2015; Schanz *et al.,* 2016), experimental approaches are based on image measurement techniques restricted to very small volumes or limited to poor resolution for longer measurement distances. The latter need accurate simulations that may strongly depend on complex unknown boundary conditions, and on a sensitive *ad hoc* tuning of turbulence model parameters. It follows that complex flows –*i.e*, large-scale three-dimensional turbulent flows– cannot be accurately analysed on the single basis of one of those two kinds of approaches. Alternative methodologies enabling a sound combination of numerical and experimental analyses are clearly needed for the reconstruction of large-scale experimental flows (Cao *et al.*, 2014). *This project aims at devising a novel methodological technique to measure and to reconstruct 3D flows involved in large-scale experiments.*

A promising approach consists in *coupling image sequences with dynamical flow models via data assimilation.* Such a strategy reveals to be a powerful methodology to resolve a complete trajectory of flow state variables from noisy and incomplete observations. Measured data guides the dynamical model, while the latter simultaneously enriches measurements by providing missing spatial scales or unobserved variables. Contrary to meteorology in which these methodologies have improved weather forecast the present project takes a whole new dimension with the incorporation of uncertainties into the dynamical turbulence flow model (Chandramouli et al., 2018) to couple large-scale numerical models and image flow visualization. This strategy will be formalized through data assimilation concepts (Gronskis et al., 2013 ; Yang et al., 2015).

References

Schanz, D. and Gesemann, S. and Schröder, A. Shake-The-Box: Lagrangian particle tracking at high particle image densities. Exp Fluids 57 (5), 70, 2016.

Cao X., J. Liu, N. Jiang, Q. Chen, Particle Image Velocimetry measurement of indoor airflow field: A review of the technologies and applications, Energy and building, 69, 367–380, 2014.

Scarano F., Ghaemi S., Caridi G.C.A., Bosbach J., Dierksheide U., Sciacchitano A., On the use of helium filled soap bubbles for large scale tomographic PIV in wind tunnel experiments. Exp Fluids 56:42, 2015

Chandramouli P., D. Heitz, S. Laizet, E. Mémin. Coarse large-eddy simulations in a transitional wake flow with flow models under location uncertainty. Under consideration for publication in Computers & Fluids, 2018.

Yang Y., C. Robinson, D. Heitz, E. Mémin - Enhanced ensemble-based 4DVar scheme for data assimilation - Computers & Fluids, 115:201-210, 2015.

Gronskis A., D. Heitz, E. Mémin. Inflow and initial conditions for direct numerical simulation based on adjoint data assimilation. J. Comput. Phys. 242:480-497, 2013.

Supervision

The PhD supervisor will be Dr. Dominique Heitz.

The PhD candidate will work closely with the members of the team Fluminance (Inria-Irstea-IRMAR), and will benefit from our collaboration with Imperial College London.

Skills and qualifications required

Master 2 level, with skills in fluid mechanics, good knowledges in applied mathematics will be appreciated.

PhD contract and term

The position is scheduled starting in 2018 for a period of 36 months.

Grossary salary per month : 1875 € (about 1500 € net)

How to apply

Send your CV and a motivation letter to Dr. Dominique Heitz (Irstea, UR OPAALE).

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