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PROPOSITION DE SUJET DE THESE

Intitulé : Particle Volume Reconstruction and 3D velocimetry using sparsity

Référence : **TIS-DTIM-2016-008**
(à rappeler dans toute correspondance)

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Sujet : 3D Particle Image Velocimetry (3DPIV) is a recent measurement technique in experimental fluid mechanics [1]. It enables the computation of 3D velocity fields on full volumes and opens the way to original fundamental characterization of turbulent flows.

3DPIV relies on tracer particles that passively follow the flow and whose image is captured by high speed cameras synchronized with laser illumination. One key step for 3DPIV is tomographic reconstruction that recovers 3D position and intensity of particles from images of at least three synchronized cameras. This step is a large scale ill conditioned inverse problem.

The actual particle density is low, so tomographic volumes are sparse. Sparsity techniques that define observed images as a combination of a small number of *atoms* in a predefined *dictionary* seem pertinent in order to regularize the associated inverse problem. Though, very few experimental demonstrations of sparsity regularized methods for 3DPIV have been proposed. One of the main difficulties is the size and the conditioning of the tomographic system as proposed in [1]. Recently ONERA proposed an alternative forward model that enables a dramatic decrease of the computational load [2][3].

The goal of the thesis is to investigate and demonstrate the true potential of sparsity concepts within the 3DPIV field and in particular of so-called l_0 nonconvex methods. The main questions of this work will be the upscaling of l_0 methods, the pertinence of positivity constraints on top of sparsity, the study of rigorous foundations for dictionary pruning [4] (such preliminary task is compulsory in order to tackle very large scale problem).

Proofs of concepts of the most promising approaches will involve dedicated experiments in ONERA Meudon and IRSTEA Rennes wind tunnels.

The thesis takes place in the cooperative research program BECOSE (BEyond COmpressive SEnsing) supported by the French Research Agency (ANR). BECOSE deals with practical and theoretical aspects of sparsity methods within the field of ill conditioned inverse problems. In the context of BECOSE, the PHD student will have the opportunity to interact with specialists of the sparsity techniques and also of the 3DPIV use case.

References :

[1] Elsinga et al., Tomographic particle image velocimetry, Experiments in Fluids, 2006

[2] Cornic et al., Fast and efficient particle reconstruction on a 3D grid using sparsity, Experiments in Fluids, 2015

[3] Barbu et al., Accelerated, Sparsity Aware Generalizations of Classical Algorithms for TomoPIV, Proceedings of PIV15, Santa Parbara, 2015

[4] Bonnefoy et al., Dynamic Screening : Accelerating First-Order Algorithms for the Lasso and Group-Lasso, IEEE TSP, 2015

Collaborations extérieures : Cédric Herzet, Fluminance, INRIA Rennes, co-directeur de la thèse

PROFIL DU CANDIDAT

Formation : Master of Science, Master of Science in Engineering

Spécificités souhaitées : Signal/Image Processing, Machine Vision, Inverse Problems, Optical measurement