PARTICLE IMAGE VELOCIMETRY: RECENT ADVANCES IN 3D IMAGING TECHNIQUES FOR FLUID DYNAMICS INVESTIGATIONS

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Abstract The presentation covers the more recent developments in the field of 3D particle image velocimetry and particle tracking for fluid mechanics experimental investigation. The attention is focused on the working principle of advanced data acquisition and processing techniques, both for time-resolved and standard double-frame PIV images. The most recent applications of these techniques are presented together with current challenges and perspective.

Particular attention is devoted to Tomographic PIV (Elsinga et al 2006) which, given its capability in providing instantaneous 3D velocity fields with a relatively high spatial resolution, candidates as a powerful tool to investigate complex fluid dynamic problems such as turbulence and transition.

A novelty aspect of Tomo-PIV, with respect to the planar and stereo techniques, is the tomographic reconstruction of the particle-tracers distribution in the 3D space from the camera images. The accuracy of the reconstruction directly affects the quality of the velocity measurement and depends strongly on the seeding density. The under-determined nature of the reconstruction problem results in spurious intensity peaks (*ghost particles*) in the reconstructed object, which have a detrimental effect on the measured velocity gradients (Elsinga et al 2011).

Since the introduction of the technique, several methods have been developed aimed to increase the accuracy and spatial resolution of Tomo-PIV, targeting both the reconstruction and the cross-correlation step.

Among these techniques, a number of studies focused on the possibility of exploiting time-resolved or multi-pulsed acquisition in order to increase the accuracy of the reconstruction of instantaneous recordings (Motion Tracking Enhancement, MTE, Novara et al 2010, Adaptive-MLOS, Atkinson et al 2010).

Furthermore, the availability of time-resolved particle fields opened to the possibility of adopting hybrid algorithms making use of particle reconstruction and tracking (Novara and Scarano 2013) and fluid parcel trajectory reconstruction (Lynch and Scarano 2014). Recently, a particle-based tracking method has been introduced by Schanz et al 2013, which avoids the voxel-based representation of 3D objects, largely improving the computational time for 3D measurements and providing accurate particle trajectory reconstruction over long sequences.

The availability of particle tracks in 3D at higher seeding density that previously available (3D-PTV, Maas et al 1993) is of particular interest when the instantaneous measurement of 3D pressure fields is concerned. In fact, the possibility of employing a non-intrusive technique for pressure measurement is of high interest for a wide range of applications, from air transport systems to wind energy. The accuracy of the pressure gradient estimation from PIV data is directly related to the material derivative calculation, which can be directly inferred from a Lagrangian description of the flow field, such as provided by particle- tracking approaches.

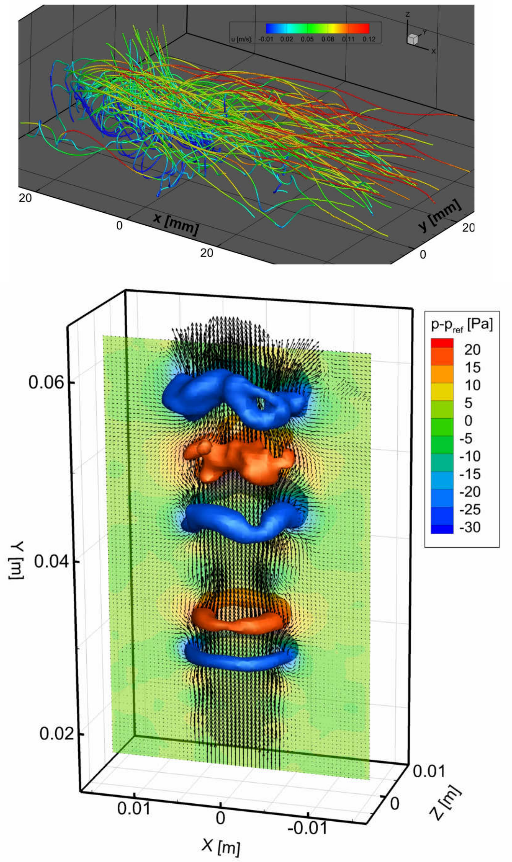

Figure1. Left: water flow over periodic hill (Re=8000). Particle tracks reconstructed over 600 time instants using the Shake-the-box algorithm (Schanz et al 2013). Right: turbulent jet flow at Re=5000. Pressure iso-surfaces obtained by particle reconstruction and tracking method (Tomo-3D-PTV, Novara and Scarano 2013).

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