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In Application

Progress in Volumetric Flow Measurement

LaVision's FlowMaster Tomo PIV applied to a turbulent jet in water at the TU Delft, Aerospace Engineering, Aerodynamic Section

TU Delft
Technische Universiteit Delft

Introduction

Conventional stereo PIV only allows the measurement of cross sections in three dimensional flow fields. Volumetric flow measurement enables time resolved 3-dimensional, 3-component velocity measurement of complete flow structures.

Recent progress of the volumetric flow measurement system FlowMaster Tomo PIV from LaVision is demonstrated using experimental data recorded at the TU Delft.

The progress includes three main features that are exemplified in this application note:

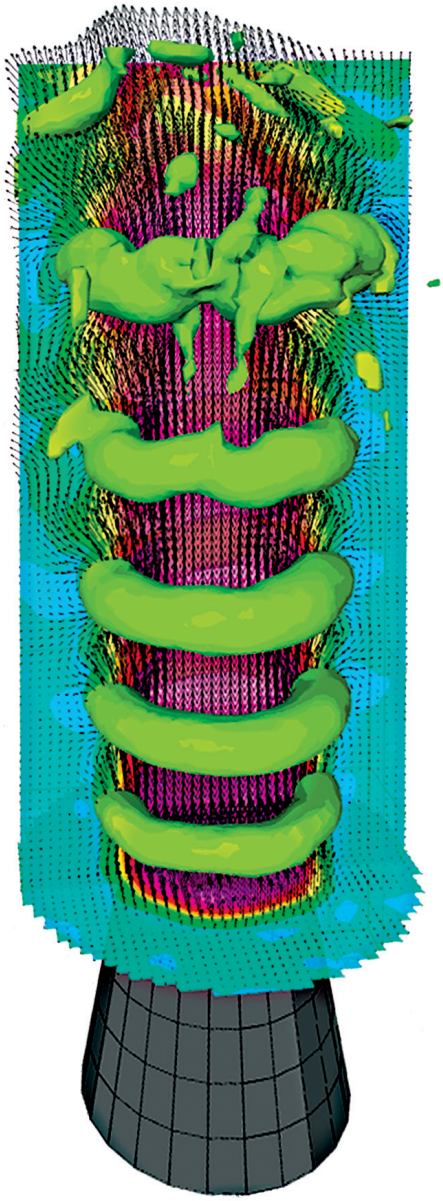
1. **Fast preview mode**
2. **3 camera Tomo PIV**
3. **Motion Tracking Enhanced reconstruction**

Experimental Setup

Time resolved jet flow in water at Re = 5000 is studied. The jet diameter is 10 mm. A high speed laser (2 x 25 mJ/pulse) illuminates a cylinder of 50 mm diameter. Four HighSpeedStar 6 cameras (1k x 1k) record instantaneous volumes of 50 x 50 x 60 mm^3 at 1.3 kHz recording rate.

picture from jet setup with LaVision's new Imager pro HS 4M cameras

Recordings at different seeding particle densities are used in the following to demonstrate the fast preview mode (low density: 0.031 particles per pixel), 3 camera Tomo PIV (moderate density: 0.055 particles per pixel) and motion tracking enhanced reconstruction (highest density: 0.17 particles per pixel).



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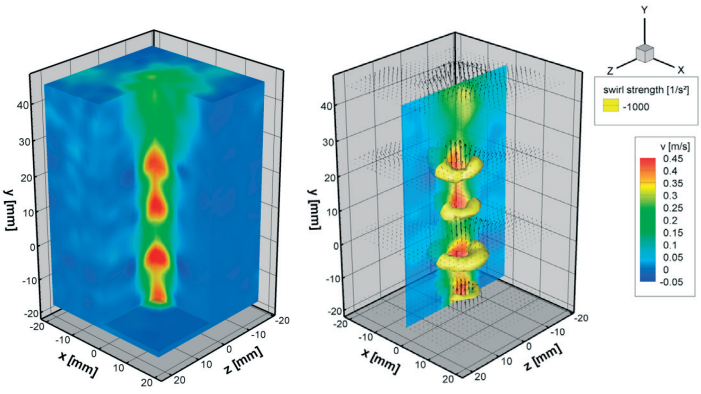
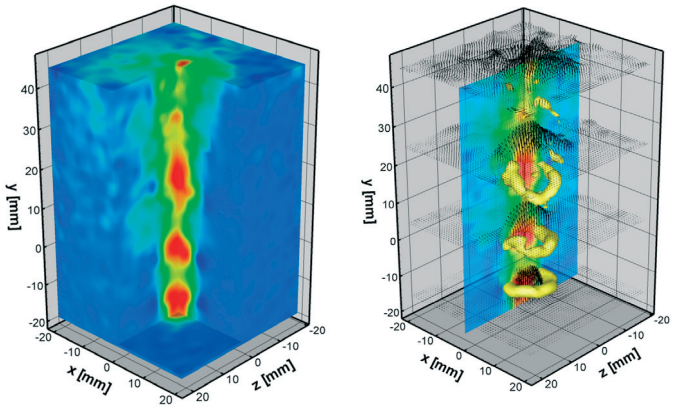
Fast preview mode

Low particle density: 0.031 particles per pixel, 4 cameras.

The fast **Multiplicative Line of Sight** reconstruction (**MLOS**), together with only 50% overlap for correlation (interrogation volume size 48³ volume elements = voxels) allows a rapid preview of the flow structure. 25 x 40 x 25 vectors already show the principal flow features after a computation time of only 85 seconds. [**MLOS** reconstruction (891 x 965 x 595voxels) + correlation (2 passes)].





3 camera Tomo PIV

Moderate particle density: 0.055 particles per pixel

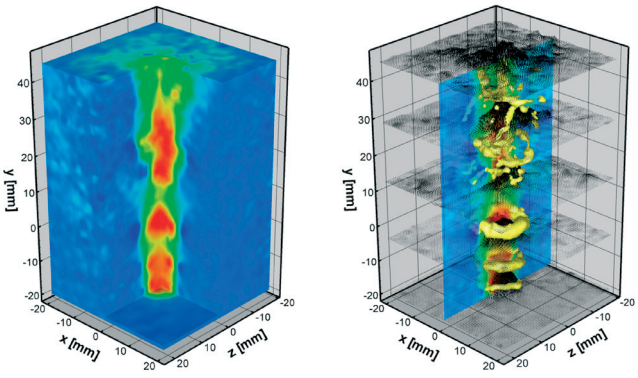
Volume Self Calibration[1)] reduces the ghost intensity at a given particle density. This allows the usage of only three cameras at moderate seeding densities.

Standard **Multiplicative Algebraic Reconstruction Technique** (**MART**)[2)] is applied for the computation of well resolved flow fields at moderate computation times. The interrogation volume size is again 48³ voxels. 75% overlap results in 51 x 81 x 51 vectors.

Motion Tracking Enhanced reconstruction

High particle density: 0.17 particles per pixel, 4 cameras

Motion Tracking Enhanced MART (**MTE**)[3)] is the reconstruction technique that allows the highest seeding particle density. Due to the high density of 0.17 particles per pixel, the interrogation volume size can be reduced to 32³ voxels. This reduction of the interrogation volume size from 48³ to 32³ results in 1.5³ = 3.4 times more vectors: 76 x 121 x 76, increasing the spatial resolution so that even small flow structures can be examined in more detail. **MTE** also leads to a significant increase of the velocity field accuracy[4)].



[1)]Wieneke B. (2008) Volume Self-Calibration for 3D Particle Image Velocimetry. Exp in Fluids 45: 549-556

[2)]Elsinga G. E., Scarano F., Wieneke B., van Oudheusden B.W. (2006) Tomographic particle image Velocimetry. Exp in Fluids 41: 933-947

[3)]Novara M., Batenburg K.J., Scarano F. (2010) Motion tracking-enhanced MART for tomographic PIV. Meas. Sci. Technol. 21 035401

[4)]Michaelis D., Novara M., Scarano F., Wieneke B. (2010) Comparison of volume reconstruction techniques at different particle densities, 15th Int Symp on Applications of Laser Techniques to Fluid Mechanics, Lisbon, Portugal

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