3D RECONSTRUCTION OF COMBUSTION FLOWS BY SYNCHRONIZED MULTICAMERA BOS

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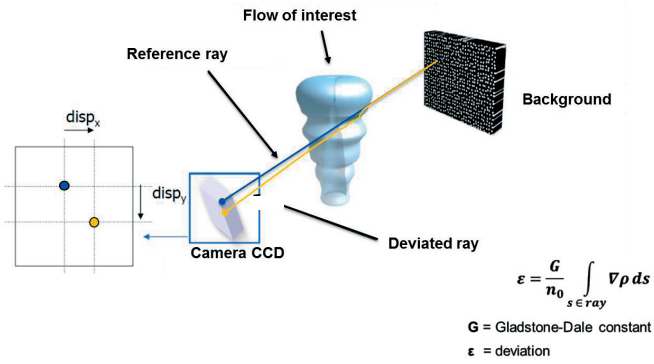
Motivation

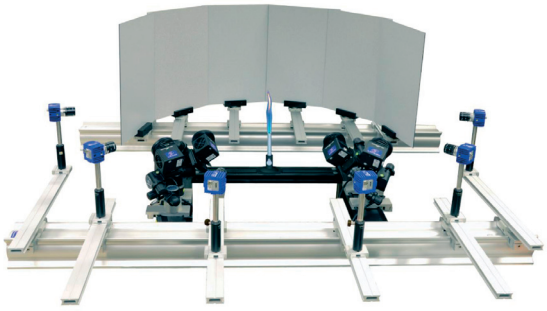
- Development of Tomo-BOS reconstruction of instantaneous flows from a synchronized multi-camera setup
- Tomographic reconstruction from a limited number of Background Oriented Schlieren images using only 6 synchronized cameras with LED illumination
- Applied to heated air jets and Bunsen flames

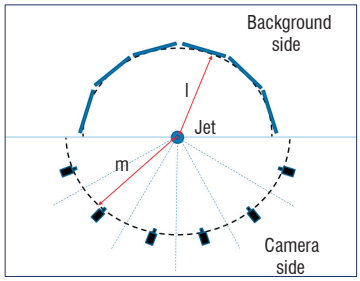
BOS technique



- BOS (Background Oriented Schlieren) is an emerging technique for quantitative measurement of density gradients, which allows 3D density field reconstruction
- Due to the line-of-sight characteristic of the BOS technique, the measurement of the density gradient of an arbitrary flow field requires:
  - synchronized acquisition from multiple views
  - 3D reconstruction based on the Algebraic Reconstruction Technique (ART)

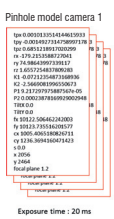
Experimental setup

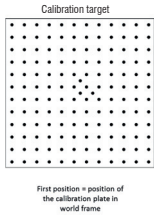


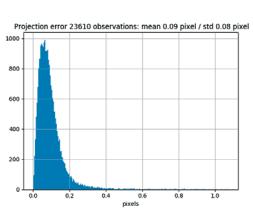


- 6 cameras (5 MPixel)
- 35-mm camera lenses
- f/# 16
- l = 500 mm, m = 700 mm
- LED illumination
- Exposure time 150 μs
- Optical resolution 0.9 mm
- Sensitivity 15 mm/rad

- BOS cameras are positioned around the object in a semi-circle
- Requires accurate geometrical calibration of the multi-camera system using a pinhole model

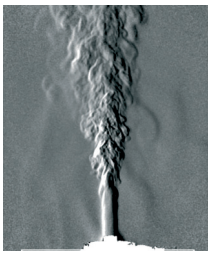


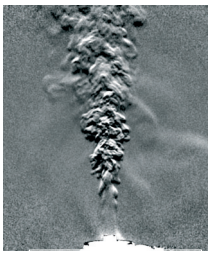


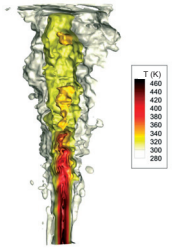


Application to heated air jet

- Nozzle inner diameter d = 9 mm
- T_j = 500 K (sensor close to heating elements ~10d upstream)
- Instantaneous realization

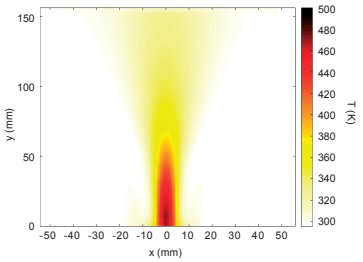

X-direction displacement map


Y-direction displacement map



- Voxel size : 0.5 mm
- Voxel number : 40 Mvoxel

- Average temperature of center plane from 400 instantaneous reconstructions

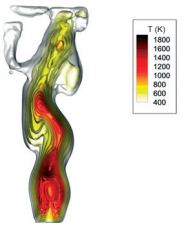


Application to combustion flows

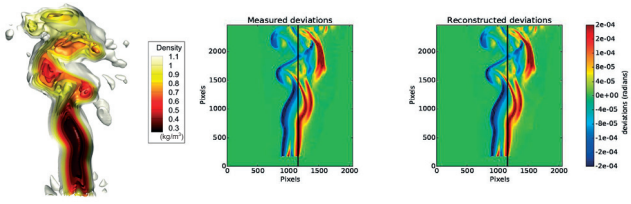
- Premixed propane/air Bunsen flame


X-direction displacement map


Y-direction displacement map



- Partially-premixed propane/air Bunsen flame



Summary

- Tomographic reconstruction obtained with only 6 synchronized cameras
- Measurement of instantaneous and average 3D temperature field in heated air jet
- Reconstruction technique applied to different Bunsen flames

Reference

Nicolas F., Todoroff V., Plyer A., Le Besnerais G., Donjat D., Micheli F., Champagnat F., Cornic P., and Le Sant Y. A direct approach for instantaneous 3D density field reconstruction from background-oriented schlieren (BOS) measurements. Experiments in Fluids, 57(1):1–21, 2016