Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institut für Fluiddynamik
ETH-Zentrum ML H35
CH-8092 Zürich

Prof. Dr. Thomas Rösgen
roesgen@ifd.mavt.ethz.ch

Lab Exercise: Particle Image Velocimetry – PIV (2012)

1. Preparation for the Lab Exercise

Read the article:

> Basics and principles of particle image velocimetry (PIV) for mapping biogenic and biologically relevant flows.
>
> Stamhuis and Eize, Aquatic Ecology, 40(4):463-479, December 2006
>
> (Link: http://www.springerlink.com/content/c2114272onl33287/fulltext.pdf)

2. General Remark

The lab exercise consists mainly of three parts: recording data, processing the data and writing a report. During the two hours of the lab session you will be able to record the data and start with some data processing.

As you will use the PIV software for the first time, you will most likely not be able to finish the processing within those two hours. Therefore you should focus on acquiring a good set of measurements during the first two hours. Since the PIV code is written in MATLAB, almost any computer at ETH Zurich can be used to do the processing outside the fixed laboratory sessions.

3. The Experiment

Goal of the exercise is to measure the flow field generated in a heated convection cell using an imaging technique called "Particle Image Velocimetry" (PIV). The flow is generated by heating a fluid (paraffin) on one side of a small glass cell. Hollow glass spheres with an approximate diameter of 10 μm and a density of 0.9 g/cm^3 are used as tracers.

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institut für Fluiddynamik
ETH-Zentrum ML H35
CH-8092 Zürich

Prof. Dr. Thomas Rösgen
roesgen@ifd.mavt.ethz.ch

The heating, which drives the convection flow, is generated by a resistive Kapton heater (Minco model HK5160) driven by a 5V power supply. With an impedance of 50 Ω it will provide approx. 0.5 W of power input to the cell which results in a flow velocity of approx 0.5 mm/s

A laser sheet is generated using a CW diode laser with an integrated light sheet optic ("Powell lens"). The laser (Lasiris SNF) is a class IIIb laser device. Any direct exposure to or visual contact with the laser beam has to be avoided.

The images are recorded with a digital camera (PCO Pixelfly, monochrome frame-interline sensor, 1280x1024 pixel resolution). The camera's maximum frame rate is about 12.8 frames/second, which is faster than necessary for the PIV interframe times required in the experiment.

4. Procedure

- Estimate the required frame separation time based on the cell convection velocity, the camera resolution and the field of view.
- Check if the estimated frame separation results in reasonable particle displacements between the two images.
- Record two sequences of more than 100 consecutive frames with different aperture settings. Store all images on disk for later processing.
- Record the image of a suitable ruler and / or the test cell edges in order to determine the image magnification (conversion pixels → mm).

5. Data Processing

To evaluate the recorded images the MATLAB software "PIV_base" is used. This software allows for the selection of different processing parameters and algorithms which can be tuned to obtain good results.

Comparisons can also be made with the results computed by a commercial software "PIVview" which is available on the lab computers.

Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Institut für Fluiddynamik
ETH-Zentrum ML H35
CH-8092 Zürich

Prof. Dr. Thomas Rösgen
roesgen@ifd.mavt.ethz.ch

6. Hints for PIV Analysis

- Before any velocity analysis is performed, the image background should be eliminated using a suitable algorithm (e.g. subtraction of the image sequence minimum).
- Experiment with different settings for the grid size, evaluation algorithms, sub-pixel interpolation and the validation of the vector field.
- Use a suitable representation (histogram, scatter plot) to check the results for signs of "peak locking" or other systematic errors in the computed velocity maps.
- Display the data using vector maps (MATLAB function "quiver") and / or streamlines.
- Try to compute and display some second order quantities of the velocity field (divergence, strain, vorticity).
- Check the MATLAB help files of the functions. There are examples that explain how to use them, as well as links to other interesting functions.

7. The Report

Document your measurements in a report with a length of 5-10 pages (maximum) either in English or in German. Submit this report in electronic format (PDF format) to the lab assistant. This document should include:

- A brief description of the experimental set-up, including:
  - The flow set-up.
  - The hardware set-up used for the experiment.
  - A discussion of the frame separation timing chosen for the experiment.
- Parameters used for the evaluation using the MATLAB PIV code and reason for the specific choices made:
  - Grid size, peak detection method for sub-pixel interpolation, outlier treatment, etc.
- Discussion of the computed flow field.
- Discussion of the influence of the aperture setting on the computed flow field.
- Discussion of the suitability of PIV for the measured flow field.
- Limitations of the technique and possible approaches to overcome them.