PARTICLE IMAGE VELOCIMETRY

Introduction

A Particle Image Velocimetry system has been purchased by the Department of Civil Engineering of Ghent University in January 2003. Particle Image Velocimetry (PIV) is a whole-flow-field technique providing instantaneous velocity vector measurements in a cross-section of a flow.

The PIV system is used in the wave flumes for research purposes. Whole field measurement techniques are especially valuable in the characterization of unsteady and turbulent flow fields (e.g. wave run-up, velocity fields behind constructions, ...) and in the validation of numerical calculations.

Principle

The flow is seeded with small tracer particles which follow the flow closely. Typically a pulsed laser beam is formed into a light sheet and is fired twice at t_0 and t_1 with a short time delay **dt**. Both illuminations are recorded by a high resolution CCD-camera. The CCD is able to capture each light pulse in separate image frames (Fig.1).

Once a sequence of two light pulses is recorded, the images are divided into small subsections called interrogation areas (IA). During the time interval **dt** between the laser shots the particles of each interrogation area have moved by a displacement **ds**. The velocity is then given by the ratio **ds/dt**. The calculation of the particle displacement **ds** is carried out by cross-correlating the two corresponding interrogation areas.

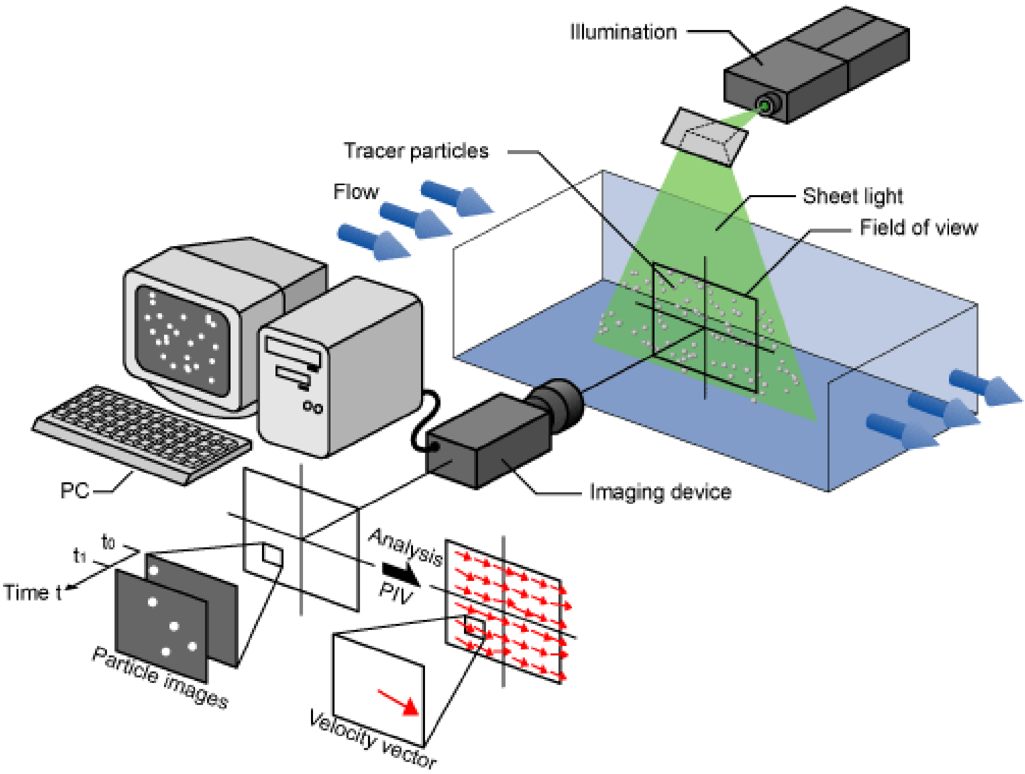

Fig. 1. *Principle of PIV measurement.*

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The position of the highest peak in the correlation plane indicates the mean displacement **ds** of the particles in a particular interrogation area (Fig.2).

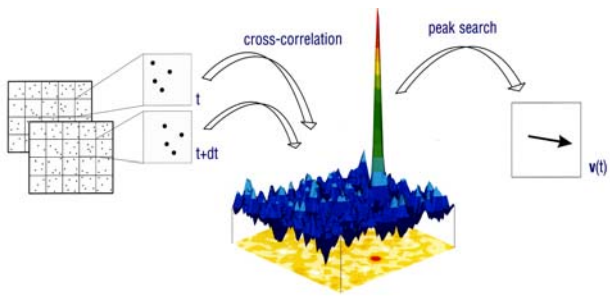

Fig. 2. Principle of cross-correlation in PIV

A complete instantaneous velocity map of the whole target area is obtained by repeating the cross-correlation for each interrogation area over the two image frames captured by the CCD camera.

Importance of seeding in PIV

Recording both light pulses in the same image frame to track the movements of the particles gives a clear visual sense of the flow structure.
For water applications, the seeding exists typically of polystyrene, polyamide or hollow glass spheres in the range 5 µm to 100 µm. Any particle that follows the flow satisfactorily and scatters enough light to be captured by the CCD camera can be used.
The number of particles in the flow is important in obtaining a good signal peak in the cross-correlation. As a rule of thumb, 10 to 25 particle images should be seen in each interrogation area.

An example of a PIV measurement performed in the wave flume is given in Fig. 3 : the wave run-up on an impermeable smooth dike is visualised.

Features

Some important advantages of the PIV technique are:

- The technique is non-intrusive and measures the velocities of micron-sized particles following the flow.
- Velocity range from zero to supersonic.
- Instantaneous velocity vector maps in a cross-section of the flow.
- With sequences of velocity vector maps, statistics, spatial correlations and other relevant data are available.

References

Raffel M., Willert C., Kompenhans J., 1998. Particle Image Velocimetry, A Practical Guide. New York, Springer, 240 p.

Contact

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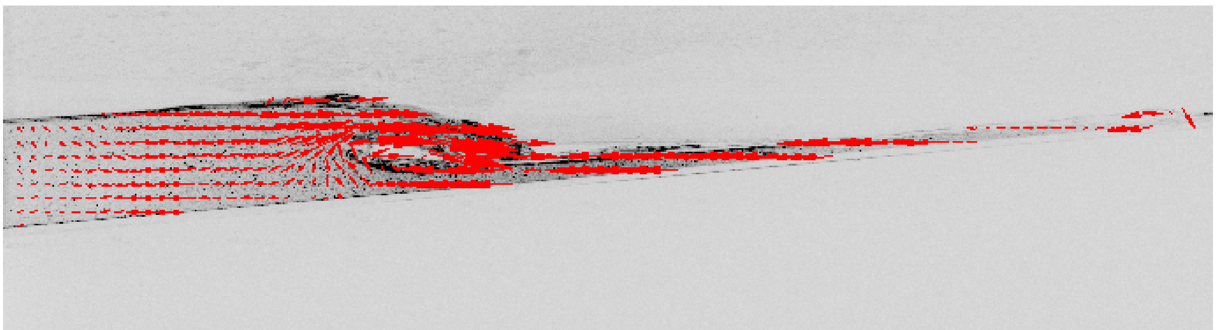

Fig. 3 Example of PIV measurement

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