An assessment of optical flow methods for river flow velocimetry

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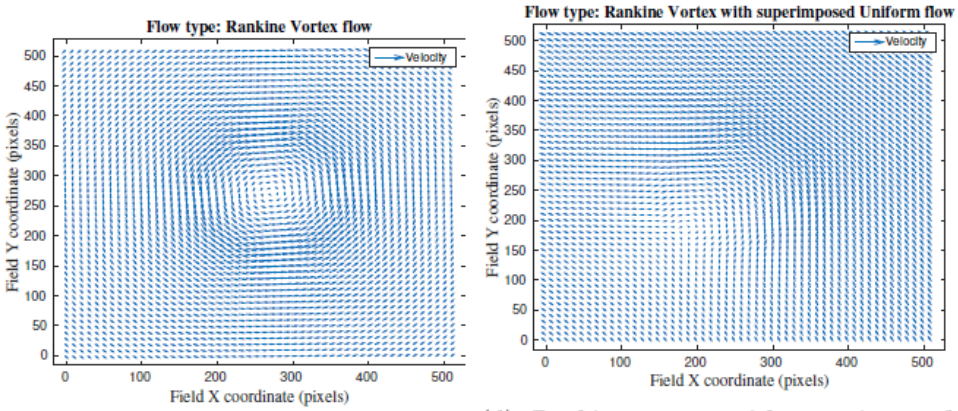
ABSTRACT

We propose an assessment of the performance of optical flow methods to estimate flow velocities from 2D Particle Image Velocimetry (PIV) images. For that purpose, we generate synthetic tracer images associated to frequent flow configurations, including: uniform flow; Rankine vortex and Rankine vortex with superimposed uniform flow (Figure 1).

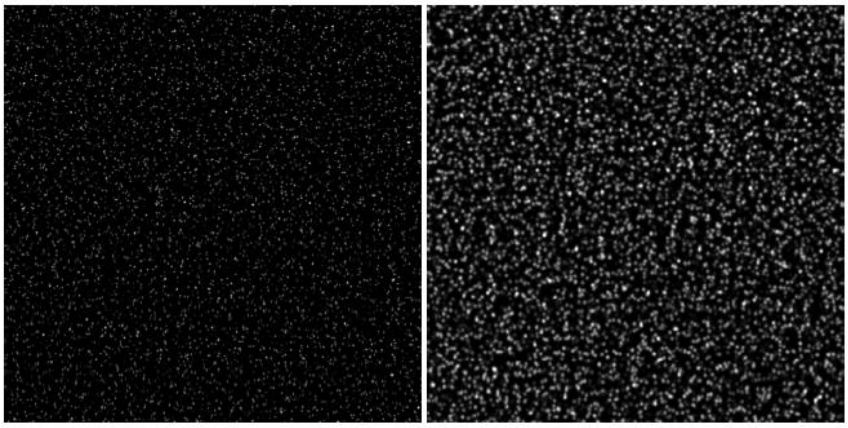


(c) Rankine vortex flow field

(d) Rankine vortex with superimposed uniform flow field

Fig. 1. Example of synthetic flows used for benchmarking: Rankine vortex (Rv) and uniform flow superimposed to Rv .

The control parameters for image generation are: particle size, number particle concentration by volume (Ni), white Gaussian image noise (WGIN), maximum flow velocity, particle out of plane movement (originated from turbulence) and laser sheet thickness. An initial distribution of tracer particles is initially generated (examples in Figure 2). The motion of all tracer particles is theoretically known with no uncertainty. All images simulate those obtained in a natural laboratory PIV environment. The true values of the flow field (ground truth) for each generated image pair are exported for validation, along with statistics of in-plane particle and out-of-plane particle losses per each image sub-area, or, interrogation area (IA) in PIV terminology. Different algorithms are compared in terms of accuracy, regarding the algorithm type, flow type, IA relative velocity, WGIN, pixel particle size and particle concentration in IA.



(a) Ni=6 and 3px diameter particles (b) Ni=6 and 6px diameter particles

Fig. 2. Synthetic images for two particle spot diameters and Ni = 6.

The assessed optical flow (OF) methods include Horn-Schunck and Farnebäck, since they are well known established optical flow methods. All methods have a preferred particle size that produces the best accuracy and is valid for all tested flows and displacements, but not necessarily the same for all algorithms. Image pre-processing also affects the accuracy and best particle size. Horn-Schunck and Farnebäck methods are suitable for flow velocities estimation from PIV images, while the former seems to achieve higher accuracy. Under special cases some OF methods have better accuracy than correlation based PIV (Figure 3).

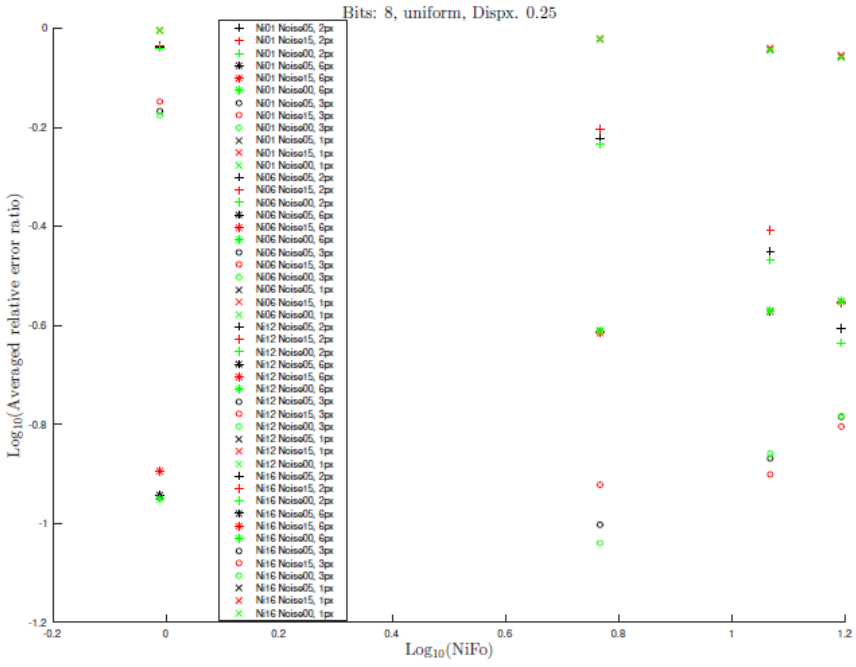


Fig. 3. Relative error (in dB) as a function of the product of image particle density (Ni) and reciprocal of fraction of out-of-plane loss of pairs.

Acknowledgements

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