Weighting the prior of a fluid dedicated optical flow estimator

D. Heitz[1], V. Navaza[1], J. Carlier[1], T. Corpetti[2] , É. Mémin[3]

1: UR TERE, Cemagref, France, dominique.heitz@cemagref.fr
2: Laboratoire COSTEL UMR 6554 LETG, Université de Rennes 2, France, thomas.corpetti@uhb.fr
3: IRISA/INRIA, Rennes, France, Etienne.Memin@irisa.fr

Keywords: optical flow, variational approach, PIV

Optical-flow based approaches used in Computer Vision minimize a two-fold robust objective function to estimate motion from image sequences. Corpetti *et al.* (2002) proposed an optical-flow scheme, dedicated to fluid motion, where the two parts (i.e the data term and the regularizer) of the proposed cost function are specifically designed to suit image sequences of fluid flows. The data term is based on a continuity equation, as a more physically-grounded alternative to the usual brightness constancy assumption. To be compatible with large displacements, the data term is used in an integrated form. The regularization term uses a second-order regularization which is able to preserve completely the divergence and vorticity structures of the flows. Using the div-curl formalism, they introduce a robust second-order regularizer which captures the divergence and the vorticity of the unknown flow.

Corpetti *et al.* (2006) tested this approach on two experimental flows, a mixing layer and the near wake of a circular cylinder. In each case, the results were compared with those of a classical correlation-based PIV treatment. It is pointed out that the main parameters values extracted with both methods have the same order of magnitude. The relevance of the obtained motion fields is then similar. A major difference comes from the number of vectors that the proposed optical flow technique is able to estimate, one vector per pixel being obtained, what opens an ability to describe a larger range of velocity scales than correlation-based PIV. Preliminary results, obtained in a turbulent plane mixing layer, showed that the dynamic range is enlarged towards smaller scales. However, from these experiments it was not possible to give an accurate validation of the dynamic range extracted with the estimator.

Recently, the assessment of the spatial resolution of this optical flow approach, highlighted the influence of the regularization parameters -- introduced to control the balance beetwen the two competing terms, namely the data term and the regularizer -- on the description of the small scales (Heitz *et al.*, 2005). In addition, these observations emphasized the need to objectify the choice of these parameters values.

In this paper, we give a first parametric investigation of a fluid dedicated optical flow estimator. From a dimensional analysis of the optical flow equations, a nondimensional regularization parameter is introduced. Then, the relation between the different main scales (luminance, space, time) with an appropriated weighting of the prior (choice of the regularization parameter) is studied and discussed. To quantify the results a spectral analysis is performed on synthetic particle images based on Direct Numerical Simulations of turbulent flows. The validity of the results obtained is also evaluated on dedicated experiments (in the wake of a circular cylinder at Re=3900), including more realistic luminance conditions. Comparisons versus classical PIV and hot-wire anemometry results are made. Finally, the question of the relevance of physical constraints with their appropriate weight is also discussed.