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High-resolution PIV with uncertainty estimation with KNN

Iacopo Tirelli, Andrea Ianiro, Stefano Discetti

Aerospace Engineering Research Group, Universidad Carlos III de Madrid, Leganés, Spain

ABSTRACT:

One of the main limitations of PIV is its spatial resolution. A large dynamic range is required to investigate the smallest scales of turbulent flows. The application of data-driven algorithms and artificial intelligence can open interesting pathways to overcome this limit. In this work we propose an approach to improve the resolution of PIV measurements using unsupervised methods to encode the main flow features, and use the K-nearest neighbors algorithm [KNN, 1] to identify groups of snapshots with similar features. Instantaneous gappy high-resolution fields are obtained from individual particle tracking; a KNN search based on the POD coefficients is then used to blend information of sets of similar fields, thus filling the gaps. This method can be considered an advancement of the data-enhanced Particle Tracking Velocimetry proposed by Cortina et al [2], in which linearity on the entire dataset was invoked, while in the method proposed herein it is only enforced locally. Interestingly, this method also produces naturally an estimation of the uncertainty by computing the standard error from the standard deviation of the vectors at each location in the set of K-neighbor fields identified for each snapshot (rectangles in Figure *1*d).

The method, named KNN-PTV, is tested on different flow conditions. In Figure *1* an example of comparison between the field obtained by the PIV (a), the DEPTV by Cortina et al [2] (b), the ground truth generated by DNS (c) and the KNN-PTV (d) is reported.

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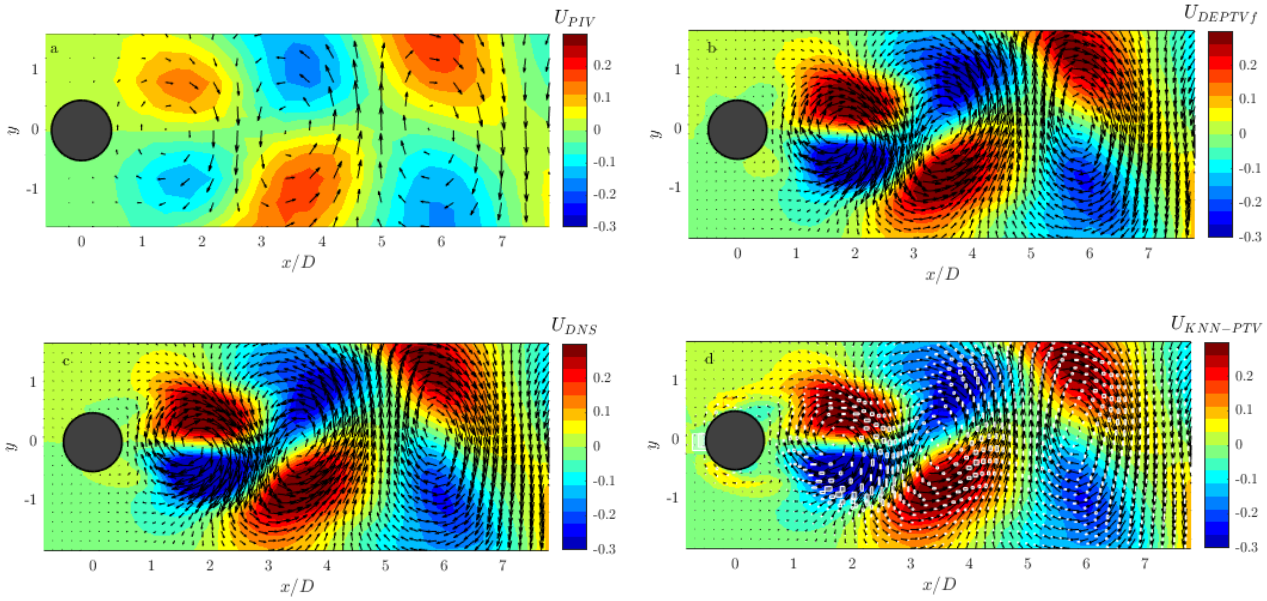

Figure 1 Comparison for a fixed time instant (10th snapshot) of the velocity component U field obtained by: a) PIV, b) DEPTV filtered by Savitzky-Golay filter, c) DNS, d) KNN-PTV. White transparent rectangles in d) indicate the uncertainty range of the KNN-PTV method.

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