Abstract Submitted
for the DFD15 Meeting of
The American Physical Society

Flow classification using machine learning on sparsely sampled experimental flow visualization data[1] ZHE BAI, STEVEN L. BRUNTON, BINGNI W. BRUNTON, J. NATHAN KUTZ, University of Washington, EURIKA KAISER, ANDREAS SPOHN, BERND R. NOACK, Institute PPRIME, France —
In this work, we consider a data-driven approach for characterizing the transitional separation bubble using video images and dimensionality reduction with supervised classification techniques to discriminate between an actuated and an unactuated flow. Flow visualizations are captured using the hydrogen bubble technique along a smooth ramp in a low-speed water tunnel, and instabilities are excited in the actuated case by oscillating a thin horizontal wire inside the boundary layer upstream of the separation. We apply clustering techniques, including the linear discriminant analysis (LDA) in a POD/PCA reduced subspace, to classify the baseline and controlled cases of the flow field from image data. With sparse subsampled pixel measurements, similar classification performance is obtained compared to that of the full-resolution images. Next, we demonstrate a sparse sensor optimization algorithm to locate a small set of pixels that optimally inform the classification task. With 5-10 specially selected sensors, the median cross-validated classification accuracy is $\geq 97\%$, as opposed to a random set of 5-10 pixels, which result in classification accuracy of 70-80%. The methods developed here apply broadly to high-dimensional data from fluid dynamics experiments.

[1]SLB and ZB acknowledge generous support from the Department of Energy (DOE DE-EE0006785). EK, AS, and BRN acknowledge additional support by the ANR SepaCoDe (ANR-11-BS09-018) and ANR TUCOROM (ANR-10-CEXC-0015).

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Date submitted: 26 Jul 2015 Electronic form version 1.4