Single-Time and Spectral Linear Stochastic Estimation of Flow Over a Backward Facing-Step – A Comparison

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In the active flow control discipline, Stochastic Estimation (SE) is a beneficial tool to predict the time-resolved flow field as it offers acceptable short-in-line processing time with higher temporal and spatial resolution. In SE, a correlation between the desired variable (for instance the velocity field) and the corresponding time-resolved point measurements obtained from a few locations must be built. These correlations are employed to estimate the desired flow property across the flow field using the time-resolved data collected from point sensors. The present work aims to study and compare two Linear Stochastic Estimation (LSE) methods, namely Single-Time and much less explored technique, Spectral Linear Stochastic Estimation using the flow over a backward-facing step as a case study. As such a comparison requires instantaneous information of the entire flow field with a high temporal resolution, and experimental measurement of the entire flow field is challenging and expensive, a very long runtime large-eddy simulation conducted by Wilkins et al.[1] that has provided time-resolved data was employed for an instantaneous comparison of the true flow field and estimate at all instances. Wall pressure fluctuations were obtained through virtual multiple-point measurements placed on the wall and were used to estimate the time-resolved flow features. Single-Time LSE showed an underpredicted velocity field by an RMS magnitude of one-third of the actual velocity field. The estimated velocity field error was lower in the point sensors neighboring areas indicating that Single-Time LSE coefficients are localized to the microphone location. The estimated velocity field was improved significantly using spectral estimation, however, most of the flow structures with middle to higher frequency were overpredicted.

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[1] Wilkins et al. *AIAA Journal* **57** (6), 2447 (2019).