

Shallow Decoder for low latency flow reconstruction using limited measurements

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Flow reconstruction using limited measurements and low latency is desirable in flow control. Erichson et al.¹ proposed a Shallow Decoder (SD) for flow reconstruction and demonstrated that SD exhibits superior performance compared to traditional methods (like POD). In this work, we use a modified SD (ModSD) to reconstruct multiple flow variables from single flow variable. ModSD learns the mapping between the sensor measurements and the corresponding flow field using a CFD dataset. We perform detailed analysis of the quality of flow reconstruction, and attempt to interpret the ModSD. We also investigate the sensitivity of flow reconstruction to the location of sensors. Various configuration of sensors, including the *optimal* sensor location suggested by Manohar et al.² is tested. We observe that flow reconstruction near the surface of cylinder and recirculation regions have relatively high accuracy. Regions that have large error are correlated with the regions of high unsteadiness. *Optimal* locations are neither optimal in terms of measure of flow reconstruction, nor in computing of drag and lift coefficients. For *optimal* locations the energy captured by ModSD, in the first mode, is highest among all the other configurations. We notice that the energy captured by second most energetic mode is less than corresponding modes of other configurations. Lower energy modes are similar to the POD modes but higher energy modes have different structures. Detailed results will be presented in the full paper.

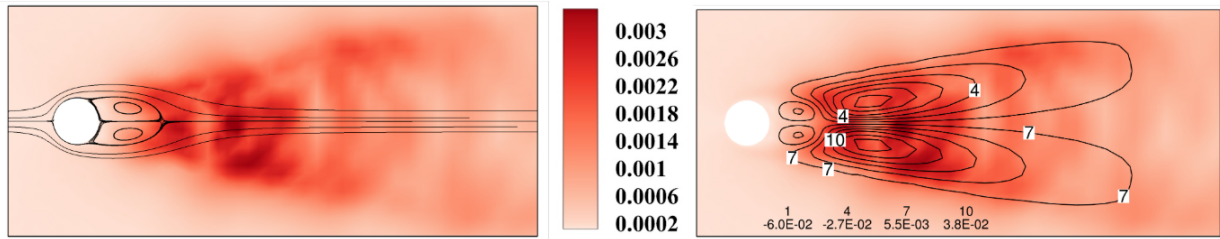


Figure 1: Root Mean Square Error in streamwise velocity component with time averaged streamlines (left) and with Reynolds stresses $u'v'$ (right) for testing data samples corresponding to *Optimal* sensor configuration

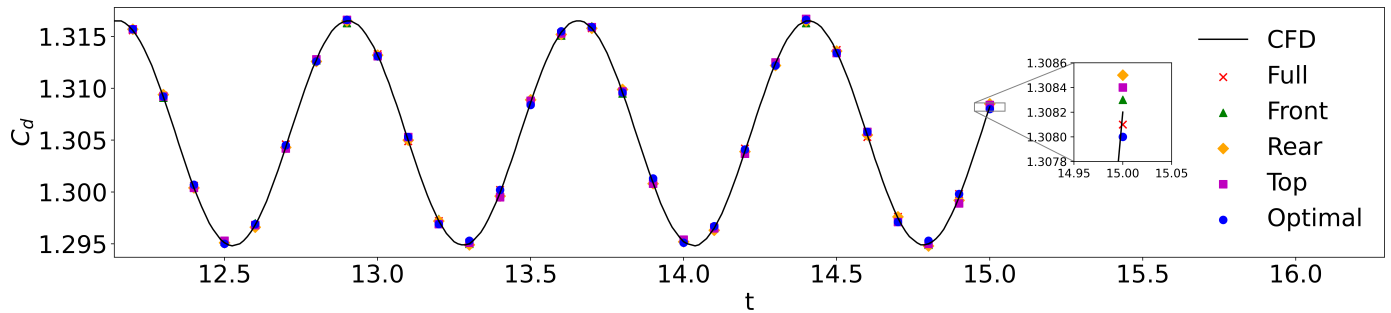


Figure 2: Comparison of time histories of drag coefficient for various sensor configurations for Testing data samples. Zoomed in-view highlights the difference among the various configurations.

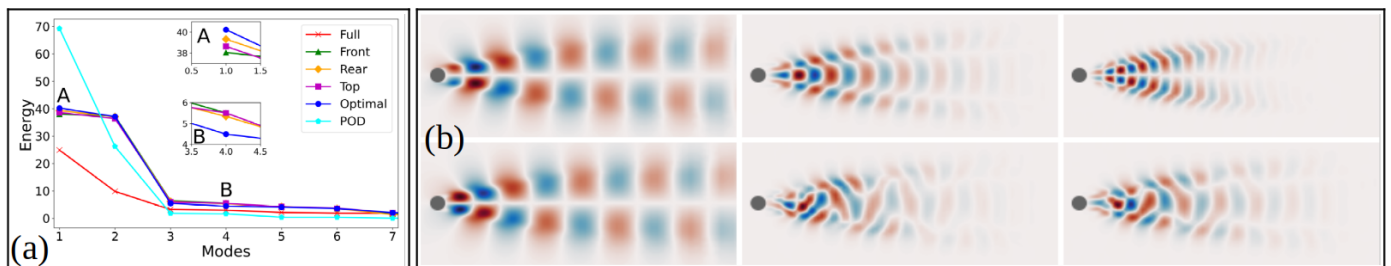


Figure 3: (a) Energy spectrum of the ModSD modes for various sensor configurations and POD modes. (b) Dominant streamwise velocity POD modes of the actual data and those captured by ModSD. Energy content of the modes decreases from left to right. *Top row*: POD *Bottom row*: Optimal.

Keywords: Flow Reconstruction, Shallow Decoder, Optimal locations

¹Erichson et al., *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences* **476** (2020).

²Manohar et al., *IEEE Control Systems* **38** (2018).