Offline optimal sensor positioning for time-resolved flow field estimation with point probes

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In a previous work Chen et al.[1] demonstrated that time-resolved flow fields estimated with point probes can be used to extract pressure fields. The method is fully data-driven and works well in convection-dominated flows since it exploits the history recorded by the probes. The optimization of probe positions can reduce the velocity/pressure reconstruction error, and even allow reducing the number of probes. In this work, the optimal position of the probes is determined for a fluidic pinball synthetic dataset. The optimum obtained for "probes with time-series" is compared with two surrogate probe positioning strategies available from flow field snapshots: sensors extracted from entire rows of the field ("row sensors"), and row sensors masked by the correlation value of any sensor position to the one in the last column ("row sensors masked"). The search is performed by one-by-one analysis of all possible position combinations.

The scatter plot of the RMS error on velocity reconstruction is shown in Fig. 1. The results for uniformly-spaced probes and for probe position optimized with QR-pivoting[2], modified to account for full-row data, are highlighted in red and green, respectively. The scatter plot for "row sensors masked" vs. "probes with time-series" (Fig. 1b) is more acute in the bottom-left corner than the "row sensors" vs. "probes with time-series" one (Fig. 1a). This indicates that the "row sensors masked" are the most effective in identifying probe position combinations with a low error when using sensors exploiting time in the reconstruction. This supports the validity of an offline probe-position selection strategy, i.e.not requiring physical probe traversing.

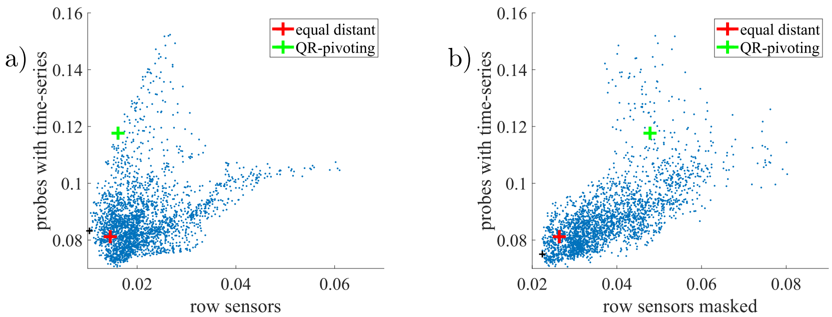

Figure 1: Scatter plots of RMS error (normalized with freestream velocity) in velocity reconstruction after traversing all 3-probe combinations for the 3 tested strategies.

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[1]Chen et al., *Exp. Therm. Fluid Sci.* **136**, 110647 (2022).

[2]Manohar et al., *IEEE Control Syst.* **38** (2018).

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