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Optimal resolvent-based estimation for flow control[1] JUNOH JUNG, University of Michigan, EDUARDO MARTINI, Universite de Poitiers, ANDRE CAVALIERI, Instituto Tecnologico de Aeronautica, PETER JORDAN, Universite de Poitiers, LUTZ LESSHAFFT, Institut Polytechnique de Paris, AARON TOWNE, University of Michigan — Obtaining accurate estimates of the flow state using limited measurements is an essential step for any closed-loop flow control strategy. In this work, we develop an optimal causal estimator formulated in terms of resolvent operators obtained from Navier-Stokes equations. This constitutes an extension of recent work that leveraged resolvent analysis to estimate space-time flow statistics and reconstruct time series from limited, non-causal measurements. In the present approach, causality is optimally enforced using a Wiener-Hopf formalism, ensuring that the current estimate depends only on current and previous measurements, making the method applicable for flow control. When equivalent assumptions are made, the approach reproduces the Kalman filter, but it can be efficiently applied to large systems without the need for prior model reduction. Unlike the Kalman filter, it can easily account for nonlinear terms from Navier Stokes with colored-in-time statistics, which significantly improves the accuracy of the estimates. Moreover, the use of the resolvent framework allows a direct physical interpretation of the mechanisms involved in the estimation procedure in terms of coherent flow structures. Finally, we show how our approach can be incorporated into an optimal control framework. Results are demonstrated using the flow over a backward-facing step.

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