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L. Ravanbod, D. Noll, J.-P. Raymond, J.-M. Buchot

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ROBUSTIFIED H_2-CONTROL OF A SYSTEM WITH LARGE STATE DIMENSION

L. Ravanbod*†, D. Noll*, J.-P. Raymond*, and J.-M. Buchot*

Abstract. We consider the design of an output feedback controller for a large scale system like the linearized Navier-Stokes equation. We design an observer-based controller for a reduced system that achieves a compromise between concurring performance and robustness specifications. This controller is then pulled back to the large scale system such that closed-loop stability is preserved, and such that the trade-off between the H_2- and H_∞-criteria achieved in reduced space is preserved. The procedure is tested on a simulated fluid flow study.

Key words: Robustified H_2-control · Navier-Stokes equation · output feedback control · reduced-order system · performance versus robustness · structured control law.

1. Introduction

Robust feedback control of systems with large state dimension like the linearized Navier-Stokes equation hinges on system reduction techniques. Bringing the system down to a moderate size allows to apply sophisticated optimization-based robust controller synthesis tools, which achieve a compromise between performance and robustness specifications. The controller so obtained is then pulled back to the large dimension, and one hopes that it still actives a similar compromise in the large scale space.

In order to justify this approach theoretically, one first of all has to prove that the pull back procedure preserves stability in closed loop (Raymond and Thevenet, 2010; Thevenet, 2009). The more intriguing question is then whether pull back also preserves the trade-off between performance and robustness specifications (Bernstein et al. 1989; Stein and Athans, 1987; Doyle et al. 1982) achieved in reduced space. Namely, stability is rarely the main issue in practical control applications. The real difficulties surface when it comes to assuring good performance and robustness in the presence of the inevitable system uncertainty.

In this work we present a new technique which allows to achieve such a compromise between performance and robustness within the framework of observer-based controllers. This may seem surprising at first, as H_2- or LQG control is known to be fragile in the presence of system uncertainty and finite energy external perturbations, which is why it has been supplanted by robust control techniques in practice (Lauga and Bewley, 2004; Farag and Werner, 2002; Lauga and Bewley, 2002; Feron, 1997; Bernstein et al. 1989; Packard and Doyle, 1987; Doyle and Stein, 1979). Since our reduction and pull-back technique makes it necessary to continue to use observer-based controllers, we have to robustify them, and this is where the use of optimization techniques becomes inevitable. In consequence, practically useful observer-based controllers can no longer be computed by solving algebraic Riccati (ARE) equations. In particular, we cannot benefit from recent progress (Benner et al. 2004) obtained in solving large-scale AREs.

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*All authors are with Université Paul Sabatier, Institut de Mathématiques, 118 route de Narbonne, 31062 Toulouse, France.

†Corresponding author.

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