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ANALYTIC GAIN SCHEDULING USING LINEAR MATRIX INEQUALITIES

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Abstract. In this paper we propose a new algorithm for analytic gain scheduling. Unlike existing methods, this approach does not require linearization around a prescribed set of operating points, or complicated interpolation schemes. Instead, a robust control law is designed for the overall nonlinear system, using linear matrix inequalities. As a result, stability can be guaranteed for large, discontinuous changes in the scheduling variable.
Keywords. Analytic gain scheduling, moving equilibria, nonlinear systems, robustness, linear matrix inequalities.

1 Introduction

Gain scheduling is a well established control design technique for nonlinear systems [1]-[9]. Although it has been used extensively in practical applications, the theoretical properties of this method have not received equal attention. Indeed, it is fair to say that many of the implementations are still based on heuristic curve-fitting, and a knowledge of the physical properties of the system.

The basic analytical framework for gain scheduling was developed by Rugh [1]. In this approach, one or more signals (or states) are identified as *scheduling variables*, which are monitored for control purposes; the feedback law is then formulated as an explicit function of these variables. To explain the main features of this method, let us consider a class of nonlinear systems described by the differential equations

$$\dot{x} = Ax + h(x) + Bu + Gp(t) \tag{1}$$

where $x(t) \in R^n$ is the state of the system, $u(t) \in R^m$ is the input vector, and $p(t)$ is a *scalar* scheduling variable. Matrices A, B and G are constant with dimensions $n \times n$, $n \times m$ and $n \times 1$, respectively, while $h : R^n \rightarrow R^n$ is a piecewise-continuous nonlinear function in x. In the following, we will assume that $p(t)$ varies in a *stepwise manner*, with sufficiently large intervals between successive changes. Such an assumption results in a quasi-static

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