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LQR Performance Comparison of Multirate vs. Single-rate Systems

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Abstract. In many practical situations, particularly in the process industry, input and output signals are not available at the same rate as is commonly assumed. Hence, control of multirate systems using existing techniques is limited by the slowest sampled signal rate. In this paper, we address the performance issue: *what are the upper and lower bounds on the performance of multirate systems?* We look at the incentive in moving from slow single-rate (SSR) control to multirate (MR) systems. We also answer the question: *can we get better performance with fast single-rate control (FSR) (sampling at faster rates)?* The main contribution of this paper is a proof using *lifting techniques* that the optimal performance of MR systems is bounded above by that of SSR systems and bounded below by that of FSR systems, with the continuous-time LQR cost function as the benchmark.
Keywords. multirate, single-rate, lifting, closed-loop performance, LQR.

1 Introduction

Multirate (MR) control is attracting significant industrial attention for several reasons. In practice, measurements from many chemical engineering systems are not available at the same sampling rate. With certain multi-time scale chemical processes, it is often uneconomical to sample all the variables at the same rate. Additionally, constraints may exist on the sampling rates of several physical variables (*e.g.*, composition estimates in a distillation column). In general, faster discretization is desired and attractive for emulating continuous-time systems and meeting certain performance specifications. Factors such as these have motivated researchers and practitioners

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