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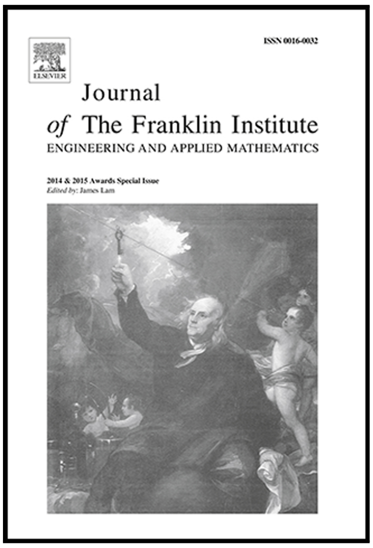

Extended Observer Based Feedback Control of Linear Systems with Both State and Input Delays

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Extended Observer Based Feedback Control of Linear Systems with Both State and Input Delays

Qingsong Liu* Bin Zhou* †

Abstract

In this paper we study the stabilization of both continuous-time and discrete-time linear systems with both state and input delays. Extended observer based controllers are designed to predict the future states such that the input delay that can be arbitrarily large yet bounded are completely compensated. Necessary and sufficient conditions guaranteeing the stability of the closed-loop systems are provided in terms of the stability of some simple time-delay systems. Some linear matrix inequalities based methods are also established to design the state feedback gains and observer gains. Two numerical examples are worked out to show the effectiveness of the proposed controllers.

Keywords: Extended observer; Delay compensation; Output feedback control; Separation principle; Stabilization.

1 Introduction

In the past several decades there has been an increasing interest in the study of the time-delay systems, and many results have been reported in the literature (see [12, 16, 37] and the references therein). As well known, stability is one of the most important fundamental problems, and has thus been extensively studied for time-delay systems. Very recently, stability analysis of linear time-delay systems was studied in [4, 29], Lyapunov stability of linear predictor feedback for systems with time-varying input delay was established in [15], a new stability condition for linear discrete-time systems was considered in [28], and the Lyapunov delay matrix and comparison of bounding methods for stability of linear time-delay systems were investigated in [6, 17]. Stability problem has also been well studied for nonlinear time-delay systems [22, 34], stochastic systems with Markovian jumping parameters [5, 7], and neural network systems [30].

Stabilization of dynamical systems in the presence of input delays is another fundamental issue in the field of control. For continuous-time time-delay systems, the stabilization problem was investigated in [9, 24], a delay-independent stabilization problem was addressed in [3] via periodically intermittent control, and a backstepping design for an exponentially unstable system was presented in [1]. For discrete-time time-delay systems, the same problem was also considered in the literature, for example, [11] and [31]. Recently, a new predictor referred to as sequential sub-predictors was established to study the stabilization of linear systems with input delay [25]. This method was then adopted to investigate the stabilization problem of nonlinear time-varying systems with input delay in [22].

All the references mentioned above mainly deal with analysis and control problems for time-delay systems in the absence of state delays. Recently, for linear systems with both state and input delays, a significative problem of compensating only input delays, that can be arbitrarily large yet exactly know, was initially studied in [38], where a nested predictor was established to predict the future states so that the input delay can be completely compensated. The same problem was independently investigated in [14] by utilizing the fundamental solution for the open-loop time-delay system. Afterwards, an alternative solution to the input delay compensation problem by adding integrators was proposed in [39]. The nested predictor feedback based approach proposed in [38] was respectively extended to neutral-type linear time-delay systems [41]

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