



Global state regulation by output feedback for feedforward systems with input and output dependent incremental rate

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Abstract

In this paper, the problem of global state regulation by output feedback is considered for a class of uncertain feedforward nonlinear systems with free-delay or time-delay states. Compared with existing results, we construct a novel observer-based controller with gain exponent to achieve the global state regulation via single output feedback under less conservative assumptions. Further, by using the Lyapunov–Krasovskii theorem, we show that the control scheme proposed is available to a class of time-delay systems with input and output dependent incremental rate. Finally, a numerical example is given to illustrate the usefulness of our results.

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1. Introduction

The problem of global output feedback control is one of the most important and challenging problems in the field of nonlinear control, which has received a lot of attention over the past decades. Compared with linear systems, the separation principle does not hold for nonlinear systems, as shown in [1]. Thus, it is necessary to impose some extra restrictive conditions on nonlinear terms to obtain global output feedback controller. In the case when uncertain nonlinear systems dominated by a lower-triangular system with linear growth in unmeasured states, the

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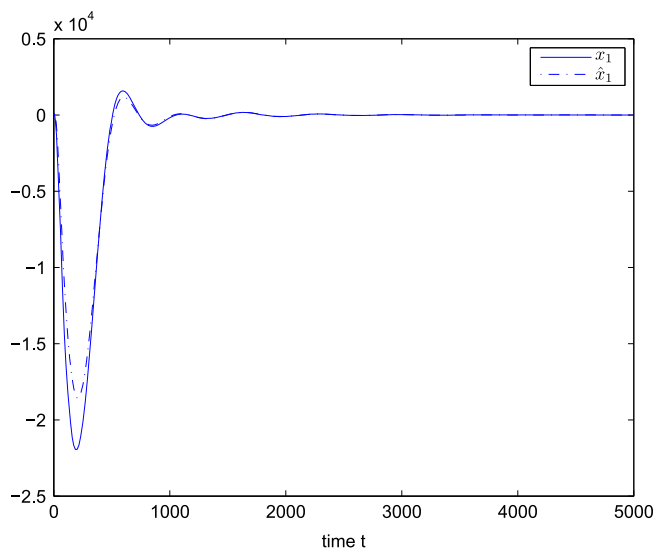


Fig. 1. The trajectories of x_1 and $\hat{x}_1$.

problems of global output feedback stabilization or regulation have been addressed in [2–4,6–13]. Specifically, using a feedback domination design method, the global exponential stabilizer was constructed under the linear growth condition with known growth rate in [2]. When the growth rate was a known smooth function of system output, the global state regulation was achieved by an adaptive output feedback controller in [3], where the results of [4,5] were generalized. With the help of switching logic, an adaptive output feedback controller was proposed in the case of unknown constant growth rate in [6]. Unlike the control scheme proposed by [6], universal adaptive high-gain observers were introduced to achieve global output feedback stabilization in [7,8]. For a larger class of nonlinear systems with unknown control coefficients, the global state regulation problem was investigated by output feedback in [9–11]. Furthermore, a universal adaptive output feedback controller was constructed for a class of nonlinear systems with unknown time delays and output function in [12], and an output feedback controller was proposed by introducing double dynamic gains in [13].

To deal with the case of high-order growth, several attempts have been made such as [14–20]. In particular, for a class of nonlinear systems with uncontrollable/unobservable linearization, the problem of output feedback stabilization was handled in [14–16]. In view of homogeneous system theory, a homogeneous domination approach was introduced to achieve output feedback stabilization in [17]. Subsequently, a generalized homogeneous domination approach was established in [18]. In the case of polynomial growth conditions, a recursive design algorithm was developed to achieve output feedback stabilization by constructing a reduced-order observer in [19]. By using dual observers, the global output feedback stabilization was achieved for nonlinear systems with lower-order and high-order nonlinearities in [20].

On the other hand, the problem of global output feedback control has been investigated for a class of feedforward nonlinear systems in [21–28]. Specifically, when triangular type restriction was not satisfied, a linear output feedback control scheme was proposed to achieve global exponential stabilization in [22]. By introducing dynamic high-gain scaling technique, an adaptive output feedback control scheme was proposed for feedforward systems in [21]. With the aid of the idea of

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