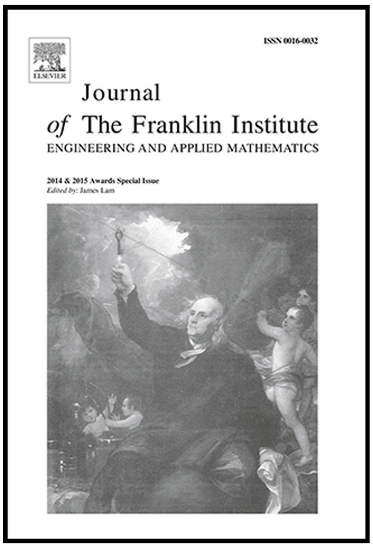

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Lantao Xing, Changyun Wen, Lei Wang, Zhitao Liu, Hongye Su

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Adaptive output feedback regulation for a class of nonlinear systems subject to input and output quantization

Lantao Xing[a], Changyun Wen[b], Lei Wang[a], Zhitao Liu[a,*], Hongye Su[a]

[a]State Key Laboratory of Industrial Control Technology, Zhejiang University, Hangzhou, 310027, P.R. China. e-mail: xlt_zju@sina.com;
[b]School of Electrical and Electronic Engineering, Nanyang Technological University, Singapore. e-mail: ecywen@ntu.edu.sg

Abstract

In this paper, we study the global stabilization problem for a class of uncertain nonlinear systems with unknown growth rate by output feedback. Both the output signal and the input signal of the system are quantized for the sake of less communication burden. To analyse the resulting discontinuous system, we adopt the non-smooth analysis techniques including the Fillipov solution and differential inclusion. A new control law with an adaptive gain is proposed to compensate for the quantization errors. It is proved that the proposed scheme ensures that all the closed-loop signals are globally bounded. In addition, the output signal can be regulated to a bounded compact set which is explicitly given.

Keywords: Input signal quantization, Output signal quantization, Adaptive control gains

1. Introduction

Nowadays, networked control is widely studied and it has been applied to various kinds of systems [1]-[6]. Signal quantization, which can largely decrease the communication burden, has gained more and more attention in networked control, see [7]-[8]. In fact, signal quantization is inherent to all the signals that need to be transmitted, including the sensor signal and the control signal. However, the challenge brought about is how to deal with the quantization errors, since the quantization error may decrease the system performance or even cause instability. Thus, the study of the quantization effects to the system is of both theoretical and practical significance.

It should be noted that existing results on quantized control are mainly based on robust approaches, see for examples [9]-[16]. On the other hand, several results about adaptive quantized control based on state feedback have been reported for a class of strict feedback nonlinear systems under some restrictive conditions [17]-[22]. Recently, the output feedback tracking control problem with quantized input signal is addressed in [23] by proposing a new quantizer. However, all these existing adaptive quantized schemes only take input quantization into consideration and cannot be applied to the cases where the state or output signals are quantized. Clearly, it is inadequate to just consider control signal quantization, as all the measurable signals for feedback (states or output) and control signal need to be transmitted through network at the same time in practice. The main difficulty encountered in these literatures lies in that their proposed schemes need differentiating the states and output to obtain the controllers, but these signals become discontinuous and thus non-differentiable after quantization. In [24], the problem of global stabilization for a class of nonlinear systems with input and output quantized by logarithmic quantizers is considered. However, the utilized logarithmic quantizer does not contain a deadzone around zero, which means infinite quantization levels are needed. This is not desirable in practice. Besides, the existing results assume that a continuous solution in the classical sense exists and is unique, even though the closed-loop system is discontinuous. How to check and ensure such an assumption has not been clearly studied.

In this paper, we consider the output feedback control problem for a class of strict feedback nonlinear systems similar to [25]. Both the output signal y and the input signal u are quantized by the quantizer proposed in [23]. The quantized signals $q_s(y)$ and $q_s(u)$ are utilized to design the state observer, which avoids the differentiability of discontinuous signals. But such design results in quantization errors. Subsequently, a new controller with an adaptive gain is designed to compensate for the effects of the quantization errors. To analyze the resulting discontinuous system dynamics, we adopt the non-smooth analysis techniques including the Filippov solution and differential inclusion. It is proved that the presented adaptive controller in this paper ensures that all the closed-loop signals are globally bounded, and the output signal can be regulated to a compact set whose size is explicitly given.

The paper is organized as follows. Section 2 briefly introduces the quantizer utilized in this paper and some background of non-smooth analysis. It also describes the system to be controlled and formulates the control problem. Section 3 proposes a scheme for designing adaptive controllers and then gives the stability analyses. Section 4 presents the simulation results,

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**Corresponding author: Zhitao Liu. E-mail:ztliu@zju.edu.cn.