ARTICLE IN PRESS

ELSEVIER

Available online at www.sciencedirect.com

ScienceDirect

Journal of the Franklin Institute ▮ (▮▮▮▮) ▮▮▮–▮▮▮

Journal of The Franklin Institute

www.elsevier.com/locate/jfranklin

Multi-instant switching control of nonlinear networked systems under unreliable wireless digital channels

Xiangpeng Xie[a,b,*], Dong Yue[a], Chen Peng[c]

[a]*Institute of Advanced Technology, Nanjing University of Posts and Telecommunications, Nanjing 210003, PR China*
[b]*School of Automation, Huazhong University of Science and Technology, Wuhan Hubei 430074, PR China*
[c]*School of Mechatronic Engineering and Automation, Shanghai University, Shanghai 200072, PR China*

Received 31 December 2015; received in revised form 15 March 2016; accepted 29 April 2016

Abstract

Integrating wireless networks in control systems allow users to take benefit from modular and flexible system design, but the analysis and design of such systems pose new challenges such as more serious packet loss. This study develops a new multi-instant switching controller of nonlinear networked systems under unreliable wireless digital channels. The proposed controller can be viewed as an improvement of previous results concerned with the homogenous polynomials approach, since it presents a denser subdivision of the joint space of multi-instant normalized membership functions and therefore essentially yields an efficient multi-instant switching mechanism for the first time. As a result, more efficient results can be obtained in the study. Finally, an illustrative example is provided to demonstrate the effectiveness of the multi-instant switching controller.

1. Introduction

During several bygone years, the fuzzy logic theory has been realized to be a powerful way to handle the problem of control synthesis for nonlinear systems. Dramatically, the Takagi–Sugeno (T–S) fuzzy model [1] has been widely applied to investigate a bank of complex nonlinear

*Corresponding author at: Institute of Advanced Technology, Nanjing University of Posts and Telecommunications, Nanjing 210003, PR China

E-mail addresses: xiexiangpeng1953@163.com (X. Xie), medongy@vip.163.com (D. Yue), c.peng@shu.edu.cn (C. Peng).

http://dx.doi.org/10.1016/j.jfranklin.2016.04.018
0016-0032/

Please cite this article as: X. Xie, et al., Multi-instant switching control of nonlinear networked systems under unreliable wireless digital channels, Journal of the Franklin Institute. (2016), http://dx.doi.org/10.1016/j.jfranklin.2016.04.018

control design problems, such as, fuzzy state/output feedback control designs [2–4], fuzzy adaptive control [5–8], fuzzy state estimation [9,10], fuzzy model reduction [11,12], fuzzy impulsive control [13,14]. And most of all, the well-known parallel distribution compensation (PDC) theory that enjoys together the same architecture as the original T–S fuzzy system has been generally employed in the control field (e.g., some important results reported in [15,16]) but the corresponding results are ordinarily with much conservatism. Therefore, a class of relaxed techniques have been proposed in succession for a purpose of reducing the conservatism, as one can examine [17–19] and the references therein. More lately, in [20], an efficient multi-instant homogenous polynomials approach has been developed to handle the problem of fuzzy control synthesis with less conservatism than previous results. However, there still exist several limitations in the underlying result: (a) the computational burden increases a lot as a trade-off, in other words, more efficient methods are required to be developed in the future; (b) an important class of information, the ranking information of the normalized fuzzy weighting functions at every different sampled points, has been ignored in the above literature all the past time. In a few words, some interesting results in this field can be obtained if one finds an efficient way to solve the involved limitations.

On the other frontier of research, networked control system (NCS) has attracted a great deal of interests [21–23] owing to its obvious superiority over the traditional point-to-point control system. On the other side of things, the application of NCS has also bringed the users with some new challenges [24,25]. Among the existing challenges, the network-induced delay and the data packet dropout are two main constituent parts. The problem of control design of NCS with network-induced delay has been in depth studied in the past decade and some promising results have been proposed in the literature, e.g., [26–29]. Recently, integrating wireless networks in control systems allow users to take benefit from modular and flexible system design, but the analysis and design of such systems pose new challenges such as more serious packet loss. There exists always one nonzero and relatively bigger probability that both the measurement and the control input may be missing during the process of wireless transmission [30–32]. As far as the PDC theory is concerned, the problem of nonlinear networked control with unreliable digital channels has been intensively addressed in [33–37]. Actually, the so-called basis-dependent Lyapunov approach was proposed in [38] but it was difficult to obtain feasible conditions in terms of linear matrix inequalities (LMIs). More recently, the authors in [39] have extended the result of [20] to control synthesis of nonlinear networked systems with unreliable digital channels. Thanking to the introduction of a useful matrix transformation lemma, LMI-based relaxed stabilization conditions are successfully provided. However, as an extension of [20], the two limitations pointed above is still unsolved in [39]. In other words, this topic is as usual challenging, which motivates us to propose this current study.

The main contribution of the study is that a new multi-instant switching controller of nonlinear networked systems under unreliable wireless digital channels is presented. The proposed controller can be viewed as an improvement of previous results concerned with the homogenous polynomials approach, since it develops a denser subdivision of the joint space of multi-instant normalized membership functions and therefore essentially yields an efficient multi-instant switching mechanism for the first time. As a result, two benefits can be obtained as follows: (1) the ranking information of the normalized fuzzy weighting functions at every different sampled points is well applied for the sake of reducing the conservatism; (2) owning to the remove of those complex augmented matrices, the computational burden in this paper is no longer as big as the existing one given in [39]. In a few words, the two limitations pointed above can be well overcome and a class of more efficient results are offered in this paper.

Please cite this article as: X. Xie, et al., Multi-instant switching control of nonlinear networked systems under unreliable wireless digital channels, Journal of the Franklin Institute. (2016), http://dx.doi.org/10.1016/j.jfranklin.2016.04.018