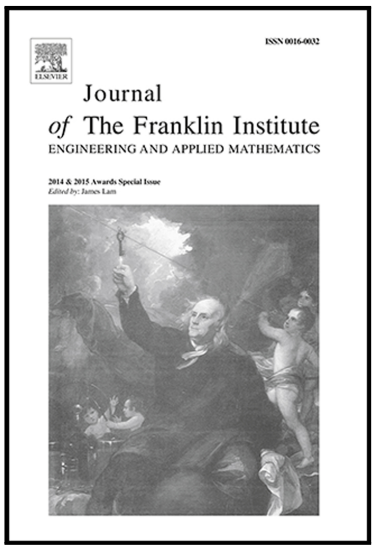

Adaptive fault-tolerant control with prescribed performance for switched nonlinear pure-feedback systems

Xuan Liu, Ding Zhai, Jiuxiang Dong, Qingling Zhang

PII: S0016-0032(17)30608-7
DOI: 10.1016/j.jfranklin.2017.11.022
Reference: FI 3232

To appear in: *Journal of the Franklin Institute*

Received date: 27 March 2017
Revised date: 24 October 2017
Accepted date: 7 November 2017

Please cite this article as: Xuan Liu, Ding Zhai, Jiuxiang Dong, Qingling Zhang, Adaptive fault-tolerant control with prescribed performance for switched nonlinear pure-feedback systems, *Journal of the Franklin Institute* (2017), doi: 10.1016/j.jfranklin.2017.11.022

Adaptive fault-tolerant control with prescribed performance for switched nonlinear pure-feedback systems

Xuan Liu[a], Ding Zhai[a]*, Jiuxiang Dong[b], Qingling Zhang[a]

[a]College of Sciences, Northeastern University, Shenyang 110819, P.R.China
[b]College of Information Science and Engineering, Northeastern University, Shenyang 110819, P.R.China

Abstract

In this paper, the problem of adaptive fuzzy fault-tolerant control is investigated for a class of switched uncertain pure-feedback nonlinear systems under arbitrary switching. The considered actuator failures are modeled as both lock-in-place and loss of effectiveness. By utilizing mean value theorem, the considered pure-feedback systems are transformed into a class of switched nonlinear strict-feedback systems. Under the framework of backstepping design technique and common Lyapunov function (CLF), an adaptive fuzzy fault-tolerant control (FTC) method with predefined performance bounds is developed. It is proved that under the proposed controller, all the signals of the close-loop systems are bounded and the state tracking error for each step remains within the prescribed performance bound (PPB) regardless of actuator faults and the system switchings. In addition, the tracking errors and magnitudes of control inputs can be reduced by adjusting the PPB parameters of errors in the first and last steps. The simulation results are provided to show the effectiveness of the proposed control scheme.

Keywords: Adaptive fuzzy control, fault-tolerant control, predefined performance bounds, switched nonlinear pure-feedback systems

1 Introduction

Backstepping control design is a recursive design methodology. With this methodology, the construction of both associated Lyapunov functions and feedback control laws is systematic. In the early stage, the key requirement for the analysis of the global stability is that the controlled nonlinear systems must satisfy the matching conditions [1, 2]. With the development of control methods, the restriction of matching conditions in nonlinear systems has been removed by the use of backstepping [3, 4, 5, 6]. However, as mentioned in [7], the backstepping technique can only be applied to those nonlinear systems with the nonlinear dynamic models known exactly or with the unknown parameters appearing linearly with respect to known functions. Consequently, a methodology called adaptive fuzzy or neural network backstepping control design was provided to solve the control problems of the nonlinear systems with unstructured uncertainties, where fuzzy logic systems (FLSs) or neural networks (NNs) are used to approximate unknown nonlinear functions [8, 9, 10, 11, 12, 13]. Subsequently, [14, 15] extended the approaches to the strict-feedback nonlinear systems. A lot of achievements have been developed for the strict-feedback nonlinear systems, but there are a few results available in pure-feedback nonlinear systems. The pure-feedback nonlinear systems[16] have a more representative form than strict-feedback systems, which makes controlling the pure-feedback nonlinear systems difficult. In fact, it is the non-affine functions that cause the difficulty of pure-feedback nonlinear systems. And the non-affine functions have no affine appearance of the state variables which can be used as virtual control signals and actual control input. Thus, only a few adaptive control scheme have been developed for pure-feedback systems. [17] advanced an effort to extend the adaptive backstepping control approach for pure-feedback systems and obtained regionally stable results. Afterwards, the problem in the control variable and virtual ones was dealt with the mean value theorem which transform the unknown non-affine input function to a partially affine form, such as [18, 19, 20]. Following this idea, by

*Correspondence to: zhaiding@163.com