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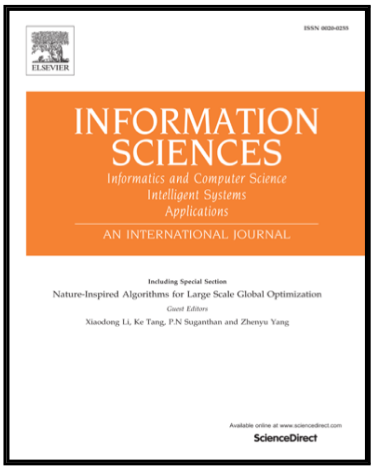

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Adaptive compensation for infinite number of actuator failures/faults using output feedback control ⋆

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Abstract

Compensation for infinite number of actuator failures/faults using output feedback control is of both theoretical and practical importance. However, it is challenging and thus still remains open so far in the field of adaptive control. In this paper, we solve this problem by proposing a new tuning function based control scheme. It is demonstrated that all the signals of the closed-loop system are globally bounded and the steady-state tracking error can be reduced as small as desired, regardless of a possibility that there are infinite number of actuator failures. Moreover, when the number of actuator failures becomes finite, our scheme further guarantees that both the tracking error and state estimation errors converge to zero asymptotically.

Key words: Adaptive control; actuator failures; fault-tolerant control; backstepping; nonlinear systems.

1 Introduction

In a practical control system, the actuator component which is used to execute control actions on the plant may suffer from failures of losing partial or total effectiveness [14–16]. In most cases, such failures and faults will lead to a severe performance degradation and even cause instability of the resulting closed-loop system. In recent years, with increasing demands for safety and reliability in life-critical systems, e.g., aircraft, manned spacecraft, etc, compensation for actuator failures has become a theoretically and practically important problem in the field of adaptive control, and many active strategies have been proposed, see for example [11, 14–16, 20–21, 25].

In [14], a direct adaptive approach for accommodating uncertain actuator failures was proposed, while the issue of compensating for actuator failures based on adaptive output feedback control was addressed in [15]. Both works are for linear systems. In [12–13], by employing the backstepping technique [5], the results in [14–15] were generalized to suit for nonlinear systems. In [16], the authors proposed a prescribed performance bounds based adaptive control scheme that can not only guarantee the perfect asymptotic tracking, but also an adjustable transient performance. Moreover, the problem of compensating for failures and faults in hysteretic actuators was overcome in [2–3]. In [29], by using state filters, an adaptive output feedback fault-tolerant control scheme for nonlinear systems was designed. However, the obtained results above are all restricted to handling finite number of actuator failures. As pointed out in [21], the failure pattern in a practical actuator may change repeatedly, e.g., the effect of poor electrical contact on actuators. This implies that the failure parameters will possibly undergo infinite number of jumps, and then the Lyapunov function, which includes these failure parameters, may also experience infinite number of jumps. In this sense, the possible increase of the Lyapunov function cannot be retained bounded automatically like [14–16], due to the accumulation of infinite number of parameter jumps. Thus, when actuator failures occur infinitely, the closed-loop system stability cannot be established by following the schemes [14–16]. In [21], an instability result has been shown through a simulation that applies a typical tuning function scheme [16] designed for accom-

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