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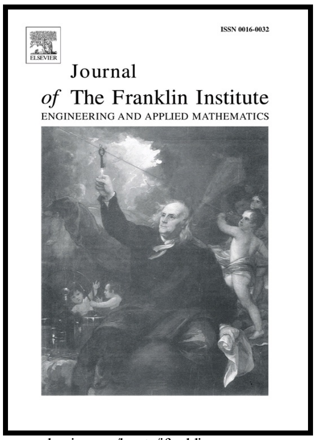

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Yana Yang, Changchun Hua, Xinping Guan

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Adaptive Fuzzy Synchronization Control for Networked Teleoperation System with Input and Multi-State Constraints

Yana Yang, Changchun Hua*, Xinping Guan

Yanshan University, Qinhuangdao 066004, China.

Abstract. Constraints are ubiquitous in physical systems, and manifest themselves as physical stoppages, saturation, as well as performance and safety specifications, among others. Violation of the constraints during operation may result in performance degradation, hazards or system damage. In this paper, the synchronization control problem for teleoperation system is investigated with input saturation and multi-state constraints in the presence of system uncertainties and asymmetric time delays. For the multi-state constraints, two types of barriers are considered: constant symmetric barriers and time-varying asymmetric barriers. An auxiliary system is designed to deal with the input saturation problem and the Fuzzy Logic system (FLs) is employed to approximate the system uncertainties. Then, new adaptive fuzzy control algorithms are designed by applying the backstepping method to provide some high performances: faster synchronization speed and higher precision. By constructing the barrier Lyapunov functions (BLF), the stability and synchronization performances are proved with the new control algorithms. Moreover, the system input and system states are prevented from transgressing the constrained region during the transient stages. Therefore, both the steady-state and transient-state performances can be guaranteed. Finally, experiment on two Phantom Premium 1.5A robots is performed to demonstrate the effectiveness of the proposed methods.

Keywords: teleoperation system; multi-state constraints; input saturation; FLs; time delays.

1. INTRODUCTION

Teleoperation system was first conceived to allow a human operator's ability to perform dangerous tasks on a remote site while the operator remains at a safe place. Compared with full-automatic system, the join of human operator makes the system more flexible. Today, applications of master-slave telerobotic systems can be found in many areas from micro to macro scales, for example, space operation, undersea exploration, handling hazardous materials, telesurgery (see [1] and the references cited therein). In recent years, many effective control strategies were developed such as PD+d (proportion differential+damping) control [2], direct force feedback [3], kinematic control [4], P+d (proportion+damping) control [5, 6], adaptive control [7] to guarantee the stability and the synchronization between the master and the slave. However, when some high performances under some physical constraints are needed, these control schemes can not up to these tasks, which finally motivates this study.

Nowadays, with ever increasingly stringent performance demands of teleoperation systems, controller designs are routinely required to simultaneously meet multiple performance objectives, such as closed-loop stability, good steady-state synchronization accuracy and fast transient response speed. However, teleoperation systems to be controlled are often subject to various types of physical constraints, such as input saturation and multi-state

*Corresponding author. Email: cch@ysu.edu.cn (C. Hua)