International Journal of Innovative
Computing, Information and Control
Volume **7**, Number **11**, November **2011**

ICIC International ©2011 ISSN 1349-4198
pp. 6559–6570

A NOVEL ISS-MODULAR ADAPTIVE NEURAL CONTROL OF PURE-FEEDBACK NONLINEAR SYSTEMS

Min Wang[1], Cong Wang[1,*] and Shuzhi Sam Ge[2]

[1]School of Automation and Center for Control and Optimization
South China University of Technology
No. 381, Wushan Road, Tianhe District, Guangzhou 510640, P. R. China
auwangmin@scut.edu.cn; *Corresponding author: wangcong@scut.edu.cn

[2]The Robotics Institute and School of Computer Science and Engineering
University of Electronic Science and Technology of China
No. 2006, Xiyuan Blvd, Gaoxin West District, Chengdu 611813, P. R. China
samge@nus.edu.sg

Received July 2010; revised November 2010

Abstract. *In this paper, an ISS-modular adaptive neural tracking control approach is presented for a class of completely non-affine pure-feedback systems combining backstepping with input-to-state stability (ISS) and small gain theorem. From the second step of backstepping, correlative interconnection terms are defined and introduced in implicit functions. Since the introduction of the correlative interconnection terms does not add any variable, radial basis function (RBF) neural networks are still valid to approximate the implicit functions as the existing results. Subsequently, the construction of the quadratic-type ISS-Lyapunov function makes the correlative interconnection terms completely eliminate the interconnected terms, so that ISS neural controller design is simplified by the combination of the small gain theorem. The proposed approach not only overcomes the difficulty in controlling non-affine pure-feedback systems, but also simplifies the stability analysis of the closed-loop system. Simulation studies are performed to demonstrate the effectiveness of the proposed scheme.*

Keywords: Pure-feedback systems, Adaptive neural control, Backstepping, Input-to-state stability, Small gain theorem

1. **Introduction.** In the past decades, backstepping approach has become one of the most popular design methods for a class of nonlinear systems with a lower triangular structure (See, for instance, [1-6] and the references therein). The basic idea of backstepping is to choose state variables of the lower triangular systems as virtual controls, design intermediate control laws for them, eliminate the interconnected term of the previous step recursively, and at last, design the true controller and the global Lyapunov function to compensate residual interconnected terms, so that the stability of the closed-loop system can be guaranteed [2]. With the help of intelligent control [7-10], most works on backstepping focus on the strict-feedback systems (See [11, 12], and the references therein) and less attention has been paid to the pure-feedback ones. In our paper, we try to study a class of completely non-affine pure-feedback nonlinear systems as follows:

$$\begin{cases} \dot{x}_i(t) = f_i(\bar{x}_i(t), x_{i+1}(t)), \quad 1 \le i \le n-1, \\ \dot{x}_n(t) = f_n(\bar{x}_n(t), u(t)), \end{cases} \tag{1}$$

where $\bar{x}_i = [x_1, x_2, \cdots, x_i]^T$, $f_i(\bar{x}_i(t), x_{i+1}(t))$ and $f_n(\bar{x}_n(t), u(t))$ are smooth and non-affine functions. The considered pure-feedback nonlinear system (1) represents a class of general lower-triangular systems due to the existence of completely non-affine structure. It