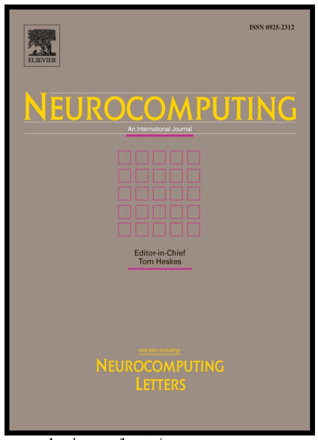
Author's Accepted Manuscript



www.elsevier.com/locate/neucom

Robust adaptive neural control for a class of non-affine nonlinear systems

Chao Shi, Xinmin Dong, Jianping Xue, Yong Chen, Jianhui Zhi

PII: S0925-2312(16)31220-6
DOI: http://dx.doi.org/10.1016/j.neucom.2016.10.029
Reference: NEUCOM17641

To appear in: *Neurocomputing*

Received date: 23 December 2015
Revised date: 3 September 2016
Accepted date: 24 October 2016

Cite this article as: Chao Shi, Xinmin Dong, Jianping Xue, Yong Chen anc Jianhui Zhi, Robust adaptive neural control for a class of non-affine nonlinea systems, *Neurocomputing,* http://dx.doi.org/10.1016/j.neucom.2016.10.029

Robust adaptive neural control for a class of non-affine nonlinear systems

Chao Shi, Xinmin Dong*, Jianping Xue, Yong Chen, Jianhui Zhi

Department of Flight control and Electrical engineering, Aeronautics and Astronautics Engineering College, Air Force Engineering University, Xi'an, Shaanxi, 710038 China

Abstract

This paper addresses the adaptive neural tracking control problem for a class of uncertain non-affine nonlinear system with non-affine function being semi-bounded and possibly non-differentiable. Compared with traditional control schemes, the proposed scheme can be applied to a more general class of non-affine nonlinear system, and relaxes constraint conditions as follows: firstly, the assumption that non-affine function must be differentiable is canceled, and only a continuous condition for non-affine function is required to guarantee the controllability of the considered system, secondly, the assumption that non-affine function is completely bounded is relaxed, and the non-affine function is constrained by a semi-bounded condition with the bounds being unknown functions. Then, an adaptive neural tracking controller is designed based on an invariant set. In the control design process, minimal learning parameter (MLP) technique is used to reduce the number of adaptive parameters, and a smooth robust compensator is employed to circumvent the influences of approximation error and external disturbance. Furthermore, it is proven that all the closed-loop signals are semi-globally uniformly ultimately bounded. Finally, simulation examples are provided to demonstrate the effectiveness of the designed method.

Keywords: Adaptive control, Neural network, Non-affine nonlinear systems, Invariant set

1. Introduction

In recent years, a lot of efforts have been made in the field of approximation-based adaptive control schemes for uncertain nonlinear systems [1-11]. Due to the universal approximation, learning and adaptation abilities of neural network (NN), the adaptive controllers involving NN approximation have achieved fairly good stability and accurate trajectory tracking for unknown nonlinear dynamics. However, most of them are applicable to the relatively simple nonlinear systems in affine form. In practice, there exist many systems with non-affine structure, such as chemical reaction [12], dynamic model in pendulum control [13], etc. Owing to few choices of mathematical tools in handling non-affine appearance of the control input, the adaptive control problem for non-affine nonlinear systems still remains challenging.

For non-affine nonlinear system, the main difficulty of controller design lies in that the control input does not appear in an affine form, and therefore, the control methods developed for affine nonlinear system cannot be directly employed to design controller for non-affine nonlinear system in general. To overcome the difficulty, some representative adaptive control schemes have been presented for non-affine nonlinear systems. In [14-16], by using a Taylor series expansion in the neighborhood of an unknown control input trajectory, the non-affine nonlinear system is transformed into an affine form, and then, adaptive fuzzy controllers are designed. However, the Taylor series expansion is only valid locally around a specified point. The mean value theorem is therefore employed to convert the non-affine function into a model of affine form since it is valid globally [17-19]. Recently, the implicit function theorem is used to demonstrate the existence of an ideal controller that can achieve control objective, and then a NN or fuzzy system is used to construct this unknown ideal implicit controller for non-affine nonlinear systems [20-23]. In [24-29], by combining the implicit function theorem with mean value theorem, adaptive NN controllers are proposed for non-affine nonlinear systems. However, it is worth noting that the common assumption of the aforementioned approaches is that non-affine function must be differentiable with respect to the control input. And to assure the controllability of the system, the partial