Adaptive backstepping control of nonlinear systems based on singular perturbation theory

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Abstract

This paper studies adaptive backstepping control of nonlinearly parameterized systems with completely non-affine property. Using parameter separation and time scale separation in back-stepping control procedure, virtual/actual control inputs are defined as solutions of a series of fast dynamic equations. Moreover, the class of systems under consideration is much more general than the previouse work and for deriving the adaptation law of unknown parameters, it is not need to designe state predictor.

Keywords: parameter separation, singular perturbation theory, nonlinear parameterization, non-affine property.

1 INTRODUCTION

Among different nonlinear systems, pure feedback systems can represent more practical process such as biochemical process, aircraft flight control system [1], mechanical systems [2], etc. In the past few years, the control of various pure-feedback systems were considered such as uncertain non-affine pure feedback systems with unknown dead zone [3], with hysteresis input [4], with output constraints [5]. Despite these efforts, control problem of completely non-affine pure-feedback systems with nonlinear parameterization has remained largely open. These systems has been considered in [6]. In this paper, adaptive control of non-linearly parameterized completely non-affine pure-feedback systems is investigated.

2 PRELIMINARIES AND PROBLEM FORMULATION

2.1 Preliminaries on singular perturbation theory

Consider the problem of solving the state equation [7]

$$\dot{x}(t) = f(t, x(t), z(t), \varepsilon),$$

$$\varepsilon \dot{z}(t) = g(t, x(t), z(t), \varepsilon), \tag{1}$$

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