Adaptive Control for Nonlinear Stochastic Hybrid Systems with Input Saturation

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Abstract

This paper presents a new state-space self-tuning control scheme for adaptive digital control of continuous multivariable nonlinear stochastic hybrid systems with input saturation. Here, the continuous nonlinear stochastic system is assumed to have unknown system parameters, system and measurement noises, and inaccessible system states. The proposed method enables the development of a digitally implementable advanced control algorithm for chaotic stochastic hybrid systems.

1. Introduction

Controls of complex interactive networks and systems present challenging problems in hybrid dynamic systems. The hybrid nature of these problems occurs at two different levels. First, at the process modeling level, the system could couple inherently continuous dynamics with network configurations that are event/logic driven. Examples of such systems include electrical power systems, transportation systems, and communication systems. At the second level, the hybrid nature may show up in the design and implementation of controls for such system. In this paper, we consider both these aspects, and provide an example of adaptive control for nonlinear stochastic hybrid systems with input saturation.

We consider the following general model of hybrid systems

$$\dot{X} = f(X) + g(X)u + w, \tag{1}$$

$$y = h(X) + v, \tag{2}$$

subject to

$$\min\,(\max)\, F_{X\in\Omega} = M(X), \tag{3}$$

$$H(X) = 0, \tag{4}$$

$$G(X) \le 0, \tag{5}$$

$$X_{\min} \le X \le X_{\max}, \tag{6}$$

where w and v are system and output measurement noises, respectively, X is a vector with n unknown decision variables, indicated as $[x_1, x_2, \Lambda, x_n]^T$, which may be continuous, discrete or hybrid variables; Ω is the solution space; F is a real-valued function in a real domain, $M(X)$ is the objective function, which is a map from solution space to real field; $X_{\min}$ and $X_{\max}$ are the bounds of X; $H(X)$ and $G(X)$ are vector functions, represented as,

$$H(X) = [h_1(X), h_2(X), \Lambda, h_{m1}(X)]^T,$$

$$G(X) = [g_1(X), g_2(X), \Lambda, g_{m2}(X)]^T,$$

$h_i(X)$ and $g_i(X)$ for all i are system functions, $m1$ and $m2$ are respectively the numbers of the equality and inequality constraints. A special case of this model was treated in [1], that describes interactions between continuous (smooth) dynamics and discrete events as it may occur in the stability analysis of electrical power and other transportation systems.

The second aspect of hybrid nature of the problem under