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AFMBC for a Class of Nonlinear Discrete-Time Systems with Dead Zone

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Abstract This paper is fretful about an adaptive fuzzy model-based controller (AFMBC), which is studied and implemented for class of nonlinear discrete-time system with dead zone. Due to immeasurable states and the presence of symmetric/non-symmetric dead zones, design of controller becomes more challenging. AFMBC is design for approximation of such nonlinear system to a relative degree of accuracy, which can be used for adaptation of nonlinear discrete-time systems with or without the presence of symmetric/non-symmetric dead zones. AFMBC employs as a reference model which is useful to closed-loop pure feedback form of fuzzy controller. AFMBC provides approximation of immeasurable states and minimizes effects of unknown bounded disturbances in the system. Based on Lyapunov method, it is proved that proposed scheme for discrete-time nonlinear systems is asymptotically stable. Hence, not only stability of proposed system is assured, but it is also shows that tracking error of model lies in closed neighbourhood of zero after sufficient number of iterations, i.e. tracking error $(e(t) \to 0$ as $t \to \infty)$. The feasibility of the AFMBC is demonstrated by well-known direct current (DC) motor example and other nonlinear discrete-time problem through simulation.

Keywords AFMBC · Discrete-time nonlinear systems · Dead zone · Lyapunov method

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1 Introduction

Famous Stone–Weierstrass theorem says that any real function $f(x)$ on a closed and bounded set can be uniformly approximated via some set of basis functions $f(x, \alpha)$ where $\alpha \in \Omega^k$ and $\Omega^k \subseteq R^k$ to a certain/arbitrary degree of accuracy [1]. The exact mathematical model of plant or industrial systems is not always possible to design and solve. Due to uncertain nature of these industrial systems, soft computing techniques employ on such type of systems. Neural networks (NN) and fuzzy logic systems (FLS) are example of such cases. In a finite-dimensional normed vector space, an uncertain nonlinear system can be approximated to a certain extent with artificial neural network (ANN) [2–4]. Approximation of nonlinear model is a more challenging comparison to linear model, and these challenges increase in the presence of dead zone or bounded disturbances. Adaptive techniques are passable to use for handling approximation of these unwanted uncertainties arising in the plant/system. Fuzzy model-based controller and adaptive neural network are adequate to be used for handling these uncertainties. Certain specific adaptive techniques like FLS and NN [5–9] for approximation of multiple-input multiple-output (MIMO) with actuator nonlinearities, multiple-input single-output (MISO) and single-input single-output (SISO) nonlinear systems were discussed. But, the above said systems does not deal about

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