Robustness Analysis of a Class of Discrete-Time Systems with Applications to Neural Networks

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Abstract: In this paper we study the robust stability properties of a large class of nonlinear discrete-time systems by addressing the following question: given a nonlinear discrete-time system with specified exponentially stable equilibria, under what conditions will a perturbed model of the discrete-time system possess exponentially stable equilibria that are close (in distance) to the exponentially stable equilibria of the unperturbed discrete-time system? In arriving at our results, we establish robust stability results for the perturbed discrete-time systems considered herein. We apply the above results in the robustness analysis of a large class of discrete-time recurrent neural networks.

Keywords: Discrete-time systems; robust stability; neural networks.

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1 Introduction

We consider discrete-time systems described by first-order ordinary difference equations of the form

\[ x(k + 1) = f(x(k)) + h(x(k)), \]  

(1)

where \( x(k) \) is a real \( n \)-vector, \( k \in \mathbb{Z}_+ \) (the set of nonnegative integers) and \( f \) and \( h \) are continuously differentiable \( n \)-vector valued functions. We view (1) as a perturbation model of systems described by

\[ x(k + 1) = f(x(k)). \]  

(2)