Hierarchical Lyapunov Functions for Stability Analysis of Discrete-Time Systems with Applications to the Neural Networks

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Abstract: In the paper the application of hierarchical Lyapunov functions is proposed for qualitative analysis of solutions of discrete-time system. General results of analysis of quasi-linear discrete system are applied to the analysis of robust stability of large-scale neural system in the case of unperturbed and perturbed equilibrium state. The obtained results are compared with those obtained via the application of vector Lyapunov function in this problem. It is shown that the application of hierarchical Lyapunov function allows us to extend the boundaries of the parameter values of the neural network for which the exponential stability of its solutions takes place. The examples illustrating the efficiency of the proposed approach are given.

Keywords: Discrete-time system; large-scale system; neural system; exponential stability; hierarchical Lyapunov function.


1 Introduction

Discrete-time uncertain systems are satisfactory models for investigation of real phenomena in populational dynamics, macroeconomics, for simulation of chemical reactions, and also for analysis of discrete Markov processes, finite and probabilistic automata and others.

One of the most actively developed areas in recent years is the dynamics of neural systems [1 – 3] which are described by discrete-time equations (see [4, 5] and the references therein). Along with the investigation of such systems under different assumptions there has been a considerable interest in the development of general approaches in stability analysis of discrete-time uncertain systems, which will be admissible in the stability analysis of neural networks.