Accepted Manuscript

Robust stability analysis of quaternion-valued neural networks with time delays and parameter uncertainties

Xiaofeng Chen, Zhongshan Li, Qiankun Song, Jin Hu, Yuanshun Tan

PII: S0893-6080(17)30086-2
DOI: http://dx.doi.org/10.1016/j.neunet.2017.04.006
Reference: NN 3745

To appear in: *Neural Networks*

Received date: 1 November 2016
Revised date: 17 February 2017
Accepted date: 14 April 2017

Robust stability analysis of quaternion-valued neural networks with time delays and parameter uncertainties[☆]

Xiaofeng Chen[a,b], Zhongshan Li[b,*], Qiankun Song[a], Jin Hu[a], Yuanshun Tan[a]

[a]Department of Mathematics, Chongqing Jiaotong University, Chongqing, 400074, China
[b]Department of Mathematics and Statistics, Georgia State University, Atlanta, GA 30302, USA

Abstract

This paper addresses the problem of robust stability for quaternion-valued neural networks (QVNNs) with leakage delay, discrete delay and parameter uncertainties. Based on Homeomorphic mapping theorem and Lyapunov theorem, via modulus inequality technique of quaternions, some sufficient conditions on the existence, uniqueness, and global robust stability of the equilibrium point are derived for the delayed QVNNs with parameter uncertainties. Furthermore, as direct applications of these results, several sufficient conditions are obtained for checking the global robust stability of QVNNs without leakage delay as well as complex-valued neural networks (CVNNs) with both leakage and discrete delays. Finally, two numerical examples are provided to substantiate the effectiveness of the proposed results.

Keywords: Quaternion-valued neural networks, Leakage delay, Discrete delay, Global robust stability, Linear matrix inequality, Modulus inequality technique.

1. Introduction

Over the past few decades, real-valued neural networks (RVNNs) and complex-valued neural networks (CVNNs) have been extensively investigated because of their widespread applications in various areas such as associative memory, pattern recognition, parallel computation, combinatorial optimization and quantum communication (Hirose, 2004; Rao & Murthy, 2008; Tanaka & Aihara, 2009; Zeng & Zheng, 2012; Rakkiyappan et al., 2014, 2015a; Song et al., 2016; Cao et al., 2016; Rakkiyappan et al., 2016). Although the number of applications of quaternion-valued neural networks (QVNNs) is comparatively less than that of RVNNs or CVNNs, it has been increasing recently. As is well-known, compared with RVNNs, the advantage of CVNNs is that they can directly deal with the two-dimensional data, which can also be processed by many neurons of RVNNs. However, there is another case where the data is three or more dimensional, such as color images, body images, 4-D signals and so on (Ujang et al., 2011; Xia et al., 2015; Zhu & Sun, 2016). Though neurons with plural real or complex numbers may be used to represent multidimensional data in neural networks, the direct encoding in terms of hypercomplex numbers may be more efficient (Matsui et al., 2004). Consequently, as a class of hyper-complex systems, QVNNs have received a growing number of studies that explore the application of quaternions to neural networks (Arena et al., 1997; Isokawa et al., 2008; Minemoto et al., 2016; Liu et al., 2016).

It is recognized that the stability of neural networks plays an essential role in their potential applications. When designing neural networks, the problem of robust stability should be investigated due to the parameter uncertainty in the system. In fact, the perturbation of parameters or system characteristics is often unavoidable. The reasons lie in two aspects: one is that the actual values of the characteristics or parameters will deviate from its design values due to the inaccurate measurement, the other is that the characteristics or parameters will drift slowly in the course of system's operation which is influenced by the environmental factors. These

[☆]This work was supported in part by the National Natural Science Foundation of China under Grant 61403051, the Program of Chongqing Innovation Team Project in University under Grant CXTDX20160102, and in part by the Natural Science Foundation of Chongqing Municipal Education Commission under Grant KJ1705138 and Grant KJ1705118.

[*]Corresponding author
Email addresses: xxffch@126.com (Xiaofeng Chen), zli@gsu.edu (Zhongshan Li), qiankunsong@163.com (Qiankun Song), windyvictor@gmail.com (Jin Hu), tanys@cqjtu.edu.cn (Yuanshun Tan)