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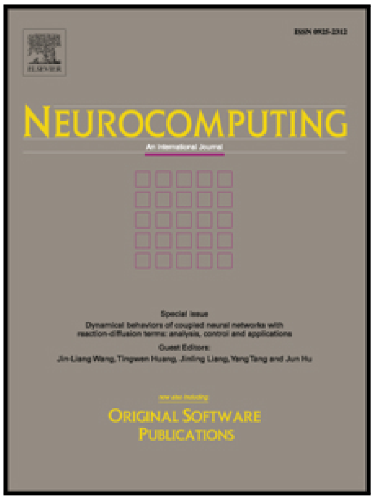

Global Exponential Stability of Neutral-Type Octonion-Valued Neural Networks with Time-Varying Delays

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Abstract

Octonion-valued neural networks (OVNNs) are a type of neural networks for which the states and weights are octonions. The octonion algebra is the only normed division algebra that can be defined over the reals, besides the complex and quaternion algebras. Being nonassociative, it clearly doesn't belong to the Clifford algebras category, which are all associative. In this paper, sufficient conditions for the global exponential stability of neutral-type OVNNs with time-varying delays are formulated, by considering two types of Lipschitz conditions that must be satisfied by the octonion-valued activation functions. To avoid the nonassociativity of the octonions and the noncommutativity of the quaternions, the OVNNs model is decomposed into 4 complex-valued systems, using the Cayley–Dickson construction. By using Lyapunov–Krasovskii functionals with double, triple, and quadruple integral terms, the free weighting matrix method, and simple, double, and triple Jensen inequalities, the stability criteria are formulated in terms of complex-valued linear matrix inequalities. Two numerical examples are provided in order to demonstrate the effectiveness and feasibility of the theoretical results.

Keywords: Octonion-valued neural networks, Neutral-type neural networks, Global stability, Linear matrix inequalities

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1. Introduction

Multidimensional neural networks have attracted interest especially over the last few years. The most developed are the complex-valued neural networks (CVNNs), which were first proposed by [1], and found applications in radar imaging, image processing, communications signal processing, antenna design, estimation of direction of arrival and beamforming, and many others [2, 3]. Another type of multidimensional networks are the quaternion-valued neural networks (QVNNs), which were proposed by [4], but became more popular in the very recent years. Their applications include chaotic time-series prediction [5], color image compression [6], color night vision [7], polarized signal classification [8], three-dimensional wind forecasting [9, 10], and others that are continuously appearing. Both types of networks have been generalized to Clifford-valued neural networks (ClVNNs), which were introduced by [11, 12], and studied by [13, 14]. They are defined on the 2^n-dimensional Clifford algebras, $n \geq 1$, of which the complex and quaternion algebras are special cases. It is expected that, in the future, ClVNNs will have applications in high-dimensional data processing.

Another type of generalization of the complex and quaternion algebras is the octonion algebra, which is 8-dimensional. It has the important property of being a normed division algebra, which means that a norm and a multiplicative inverse can be defined on it. In fact, it can be proved that the complex, quaternion, and octonion algebras are the only normed division algebras that can be defined over the field of real numbers. The octonion algebra is noncommutative, but also nonassociative, which shows that it is not a special case of the Clifford algebras, because these algebras are all associative.

Octonions have found applications, among others, in geometry [15], physics [16], and signal processing [17]. In physics, they were used as a means to reformulate the Dirac equation [18], electrodynamics and

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