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Two finite-time convergent Zhang neural network models for time-varying complex matrix Drazin inverse

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ABSTRACT

This paper concerns the computation of the Drazin inverse of a complex time-varying matrix. Based on two Zhang functions constructed from two limit representations of the Drazin inverse, we present two complex Zhang neural network (ZNN) models with the Li activation function for computing the Drazin inverse of a complex time-varying square matrix. We prove that our ZNN models globally converge in finite time. In addition, upper bounds of the convergence time are derived analytically via the Lyapunov theory. Our simulation results verify the theoretical analysis and demonstrate the superiority of our ZNN models over the gradient-based GNN models.

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1. Introduction

The Drazin inverse has many applications, such as singular differential or difference equations and Markov chains. Iterative methods for computing the matrix Drazin inverse can be found in [5,6,11,35–37].

The neural network approach to parallel computing and signal processing has been successfully developed through a variety of neurodynamic models with learning capabilities [14,22]. Various types of neural networks have been introduced to solve systems of linear algebraic equations.

A number of nonlinear and linear Hopfield-type recurrent neural network models were recently developed for computing the regular inverse of a nonsingular matrix and the generalized inverses of a full-rank rectangular matrix, see [17,24,29,30]. A method with high convergence rate for finding approximate inverses of nonsingular matrices was suggested and established analytically in [25]. In particular, a feedforward neural network architecture for computing the Drazin inverse A^{D} of a square matrix A was proposed in [8]. Various recurrent neural networks (RNN) for computing the generalized inverses of rank-deficient matrices are presented in [31,34]. In [28], an RNN with linear activation functions for computing the Drazin inverse of a square matrix was proposed by Stanimirović, Zivković and Wei. The dynamic equation and its corresponding artificial RNN for computing the Drazin inverse of a square real matrix, with no restrictions on its eigenvalues, were presented in [27]. Four gradient-based recurrent neural networks (RNNs) for computing the Drazin inverse of a square real matrix were developed in [32].

A new type of complex-valued Zhang neural network (ZNN) was proposed and investigated in [20]. The ZNN models for computing the Moore–Penrose inverse of an online time-varying and full-rank matrix are investigated and analyzed in [42]. The design of the ZNN models is based on an indefinite error-monitoring function, called Zhang function (ZF), which can be real, complex, positive, zero, negative or unbounded. The ZF plays an important role in the development of the ZNN, and largely enriches the theory of the ZNN.

Complex matrices occur in situations where the problem contains online frequency domain identification processes, or the input signals incorporate both the magnitude and phase information [15,26]. Thus, problems in the complex domain have attracted extensive attention, [3,12,13,15,16,26,38]. Furthermore, there are applications involving the computation of the Drazin inverse of a time-varying matrix [1,4,41]. Two types of the ZNN models with various activation functions for computing the online time-varying Drazin inverse were proposed, investigated and analyzed by Wang, Wei and Stanimirović in [33].

In this paper, based on the idea of the ZF, we design two ZNNs for the online solution of the Drazin inverse of a time-varying complex matrix. In addition, inspired by the study of finite-time convergence [2,18,19,21,23,39], we use a novel activation function, called the Li activation function [18,19,21], to accelerate the ZNN to finite-time convergence to the Drazin inverse of a time-varying complex matrix.

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