

Accepted Manuscript

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PII: S0377-0427(17)30489-2
DOI: <https://doi.org/10.1016/j.cam.2017.09.048>
Reference: CAM 11328

To appear in: *Journal of Computational and Applied Mathematics*

Received date: 22 April 2016
Revised date: 2 June 2017

Please cite this article as: P.S. Stanimirović, S. Srivastava, D.K. Gupta, From Zhang Neural Network to scaled hyperpower iterations, *Journal of Computational and Applied Mathematics* (2017), <https://doi.org/10.1016/j.cam.2017.09.048>

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From Zhang Neural Network to scaled hyperpower iterations

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Abstract

A class of scaled hyperpower iterative methods for computing outer inverses is considered. This class appears during the construction of the discrete-time Zhang neural network for computing the usual matrix inverse. The usual hyperpower iterative methods belong to this class. Additionally, a more general class of scaled iterative methods, which includes the scaled hyperpower method, is defined and studied. Different values of the real scaling parameter are investigated both theoretically and numerically.

AMS Subj. Class.: 15A09, 65F30.

Key words: Outer inverse, Discrete Zhang Neural Networks, Moore-Penrose inverse, iterative methods, convergence.

1 Introduction and preliminaries

Following the usual notation, the set of all $m \times n$ complex matrices of rank r is denoted by $\mathbb{C}_r^{m \times n}$. Further, $\|A\|_2$, A^* , $\mathcal{R}(A)$ and $\mathcal{N}(A)$ denote the matrix 2-norm, the conjugate transpose, the range space and the null space of $A \in \mathbb{C}^{m \times n}$. In addition, $\text{rank}(A)$ denotes the rank of a given matrix A . For $A \in \mathbb{C}^{n \times n}$, the smallest nonnegative integer j such that $\text{rank}(A^{j+1}) = \text{rank}(A^j)$ is called the index of A and is denoted by $\text{ind}(A)$. The key point in the investigation and computation of generalized inverses of $A \in \mathbb{C}_r^{m \times n}$ leads to, so called, Penrose equations

$$(1) \quad AXA = A \quad (2) \quad XAX = X \quad (3) \quad (AX)^* = AX \quad (4) \quad (XA)^* = XA$$

for unknown matrix X . By $A\{\mathcal{S}\}_s$ we denote the set of all \mathcal{S} -inverses of A which are of rank s . A single element of the set $A\{1, 2, 3, 4\}_r$ is called the Moore-Penrose inverse A^\dagger of A .

The Drazin inverse of a square matrix $A \in \mathbb{C}^{n \times n}$ is the unique matrix $X \in \mathbb{C}^{n \times n}$ which fulfills the matrix equation (2) in conjunction with

$$(1^k) \quad A^{l+1}X = A^l, \quad l \geq \text{ind}(A), \quad (5) \quad AX = XA,$$

and it is denoted by $X = A^D$ (for more details see [17]). In the case $\text{ind}(A) = 1$, the Drazin inverse becomes the group inverse $X = A^\#$. The outer inverse of $A \in \mathbb{C}_r^{m \times n}$ with prescribed range T and null space S , denoted by $A_{T,S}^{(2)}$, satisfies the matrix equation (2) and two additional properties: $\mathcal{R}(X) = T$

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