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Decompositions of a matrix by means of its dual matrices with applications[☆]

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Abstract

We introduce the notion of dual matrices of an infinite matrix A , which are defined by the dual sequences of rows of A and naturally connected to the Pascal matrix $P = \left[\binom{i}{j} \right] (i, j = 0, 1, 2, \dots)$. We present the Cholesky decomposition of the symmetric Pascal matrix by means of its dual matrix. Decompositions of a Vandermonde matrix are used to obtain variants of the Lagrange interpolation polynomial of degree $\leq n$ that passes through the $n + 1$ points (i, q_i) for $i = 0, 1, \dots, n$.

Keywords: Dual sequence, Dual matrix, Vandermonde matrix, Hankel matrix, Toeplitz matrix, Lagrange interpolation polynomial

2010 MSC: 15B05, 11B39, 11B65

1. Introduction

Let \mathbf{R}^∞ denote the infinite dimensional real vector space consisting of all real sequences $\mathbf{a} = (a_0, a_1, a_2, \dots)^T$, and let $\Delta \mathbf{a}$ denote the *difference sequence* of \mathbf{a} , defined by:

$$\Delta \mathbf{a} = (\Delta a_0, \Delta a_1, \Delta a_2, \dots)^T,$$

where $\Delta a_i = a_{i+1} - a_i$ for each $i = 0, 1, 2, \dots$. Let $\Delta^k \mathbf{a} = (\Delta^k a_0, \Delta^k a_1, \Delta^k a_2, \dots)^T$, $k = 0, 1, 2, \dots$, be the k th difference sequence defined inductively by $\Delta^k \mathbf{a} = \Delta(\Delta^{k-1} \mathbf{a})$, where $\Delta^0 \mathbf{a} = \mathbf{a}$. For a sequence $\mathbf{a} = (a_0, a_1, a_2, \dots)^T \in \mathbf{R}^\infty$, let $\mathbb{M}^{\mathbf{a}}$ denote the *difference matrix* of \mathbf{a} defined by:

$$\mathbb{M}^{\mathbf{a}} = \begin{bmatrix} \mathbf{a}^T \\ (\Delta \mathbf{a})^T \\ (\Delta^2 \mathbf{a})^T \\ \vdots \end{bmatrix} \quad (1.1)$$

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