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Least-squares solutions of generalized linear systems and the matrix equation $AXB = C$ under the general semi-tensor products

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AbstractFull Text(HTML)Download PDF

We investigate least-squares (LS) solutions of Sylvester-type matrix equations formulated via the general semi-tensor product (GSTP) of matrices. In particular, we consider generalized linear systems of the form $A \ltimes x = B$, where A and B are given rectangular matrices and x is an unknown column vector, with $\ltimes$ denoting the GSTP that extends both the conventional matrix product and the semi-tensor product. By analyzing the derivative of the LS error associated with the equation, we show that LS solutions can be obtained by solving an equivalent linear system under the usual matrix product. Using matrix partitioning techniques, these results are further extended to several Sylvester-type equations, including $A \ltimes X = B$, $X \ltimes A = B$, and $A \ltimes X \ltimes B = C$, where X is an unknown matrix of compatible size. This framework unifies the classical and semi-tensor product cases under a generalized algebraic setting. Furthermore, we develop a gradient-descent iterative algorithm to compute approximate LS solutions efficiently. Numerical experiments confirm the convergence, capability, and effectiveness of the proposed method.

Keywords: Sylvester-type matrix equations, semi-tensor product, least-squares solution, matrix derivative, Kronecker product

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