The LSQR method for solving tensor least squares problem

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Abstract

In this paper, we are interested in finding an approximate solution $\hat{\mathcal{X}}$ of the tensor least squares minimization problem
$\min_{\mathcal{X}} \left\| \mathcal{X} \times_1 A^{(1)} \times_2 A^{(2)} \times_3 \cdots \times_N A^{(N)} - \mathcal{G} \right\|$ where $\mathcal{G} \in \mathbb{R}^{J_1 \times J_2 \times \cdots \times J_N}$ and $A^{(i)} \in \mathbb{R}^{J_i \times I_i}$ $(i = 1, \ldots, N)$ are known, and $\mathcal{X} \in \mathbb{R}^{I_1 \times I_2 \times \cdots \times I_N}$ is the unknown tensor to be approximated. Our approach is based on two steps. Firstly, we apply the CP or HOSVD decomposition to the right-hand side tensor $\mathcal{G}$. Secondly, we perform the well-known Golub-Kahan bidiagonalization to each coefficient matrix $A^{(i)}(i = 1, \ldots, N)$ to obtain a reduced tensor least squares minimization problem. This type of equations may appear in color image and video restorations as we described below. Some numerical tests are performed to show the effectiveness of our proposed method.

Keywords: HOSVD, CP decomposition, color image restoration, video restoration, LSQR

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