Low-tubal-rank Tensor Analysis: Theory, Algorithms and Applications

Jianjun Wang
School of Mathematics and Statistics, Southwest University, China
Email: wjj@swu.edu.cn

This talk will share our two recent results on low-tubal-rank tensor analysis. (1) ***LRTR:*** we establish a regularized tensor nuclear norm minimization (RTNNM) model for low-tubal-rank tensor recovery (LRTR). Then, we initiatively define a novel tensor restricted isometry property (t-RIP) based on tensor singular value decomposition (t-SVD). Besides, our theoretical results show that any third-order tensor $\mathbf{X} \in \square^{n_1 \times n_2 \times n_3}$ whose tubal rank is at most r can stably be recovered from its as few as measurements $\mathbf{y} = \mathrm{M}(\mathbf{X}) + w$ with a bounded noise constraint $||w||_2 \leq \grave{o}$ via the RTNNM model, if the linear map M obeys t-RIP with $\delta_{tr}^{M} < \sqrt{(t-1)/(n_3^2+t-1)}$ for certain fixed $t > 1$. (2) ***TRPCA:*** by incorporating prior information including the column and row space knowledge, we investigate the tensor robust principal component analysis (TRPCA) problem based on t-SVD. We establish sufficient conditions to ensure that under significantly weaker incoherence assumptions than tensor principal components pursuit method (TPCP), our proposed Modified-TPCP solution perfectly recovers the low-tubal-rank and the sparse components with high probability, provided that the available prior subspace information is accurate. In addition, we present an efficient algorithm by modifying the alternating direction method of multipliers (ADMM) to solve the Modified-TPCP program. Numerical experiments show that the Modified-TPCP based on prior subspace information does allow us to recover under weaker conditions than TPCP. The application of color video and face denoising task suggests the superiority of the proposed method over the existing state-of-the-art methods.

Keywords: : Low-rank tensor recovery, tensor singular value decomposition, tensor restricted isometry property, regularized, tensor robust principal component analysis, prior subspace information, ADMM.