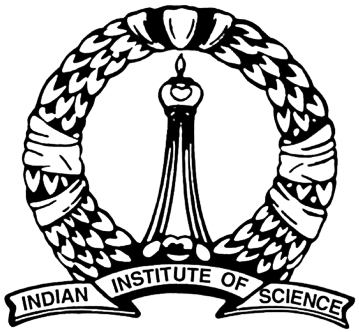
A Dual Framework for Low-rank Tensor Completion

Madhav Nimishakavi, Pratik Jawanpuria, and Bamdev Mishra



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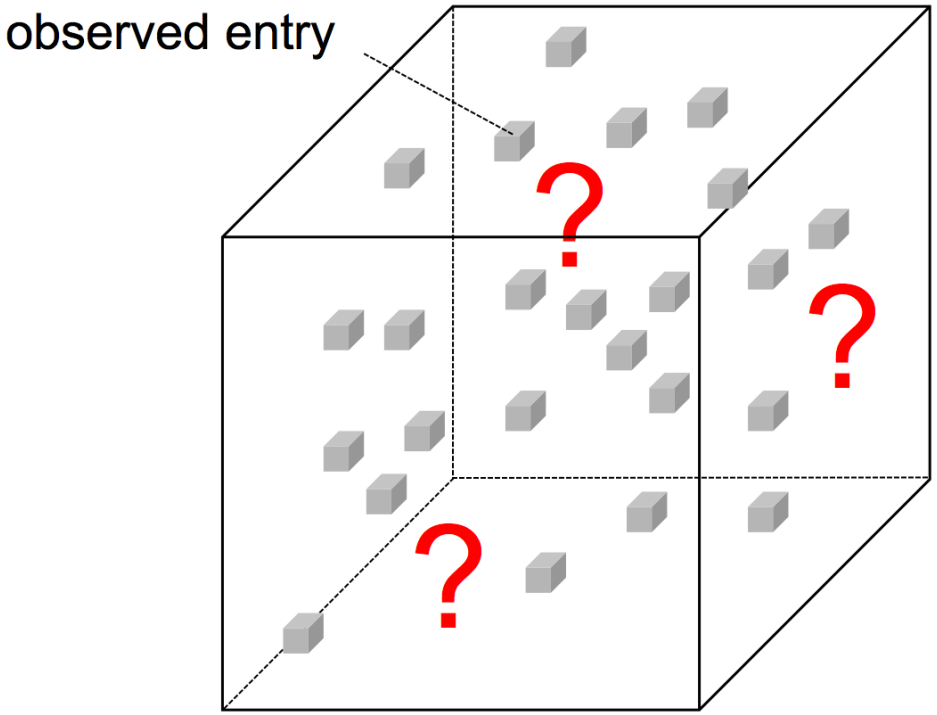
Low-rank tensor completion

Given an incomplete tensor $\mathcal{Y}_\Omega$ with $|\Omega|$ entries



Aim: Complete tensor subject to low-rank constraint

We propose a novel low-rank tensor modeling with particular latent tensor norm

Optimization with mixture of tensors:

Primal formulation

$$\min_{\mathcal{A},\mathcal{B},\mathcal{C}} \ \lambda\|\mathcal{W}_\Omega - \mathcal{Y}_\Omega\|_F^2 + \underbrace{\|\mathcal{A}_1\|_*^2 + \|\mathcal{B}_2\|_*^2 + \|\mathcal{C}_3\|_*^2}_{\text{Low-rank regularizer}},$$

where $\mathcal{W} = \mathcal{A} + \mathcal{B} + \mathcal{C}$ is the learned tensor.

$\mathcal{A}_1$ is the matrix unfolding of $\mathcal{A}$ along mode 1.

$\| \quad \|_*$ is the nuclear norm of a matrix.

Latent tensor norms have been studied earlier [Tomioka and Suzuki, 2013, Tomioka et al., 2010].

The dual framework leads novel insights into the primal solution space

Our novel tensor decomposition

$$\mathcal{A} = \mathcal{Z} \times_1 U_1 U_1^\top$$
$$\mathcal{B} = \mathcal{Z} \times_2 U_2 U_2^\top$$
$$\mathcal{C} = \mathcal{Z} \times_3 U_3 U_3^\top$$

where $\mathcal{Z}$ is a sparse tensor with $|\Omega|$ entries.
U_1, U_2, and U_3 are in the spectrahedron manifold

$\mathcal{A}$, $\mathcal{B}$, $\mathcal{C}$ share the same $\mathcal{Z}$.

Proposed conjugate gradient and trust-region algorithms

The dual optimization problem is formulated over a product of spectrahedron manifolds.

For additional details please visit our poster

Paper and codes available at www.bamdevmishra.com

Coded with Manopt, a Matlab toolbox for optimization on manifolds

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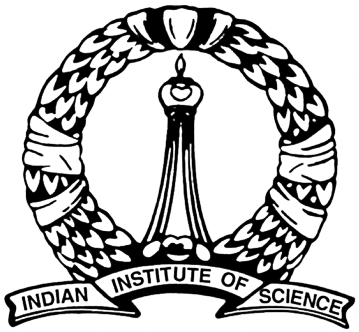

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R. Tomioka and T. Suzuki. Convex tensor decomposition via structured schatten norm regularization. In *NIPS*, 2013.

R. Tomioka, K. Hayashi, and H. Kashima. Estimation of low-rank tensors via convex optimization. Technical report, arXiv preprint arXiv:1010.0789, 2010.