Multi-Mode Deep Matrix and Tensor Factorization

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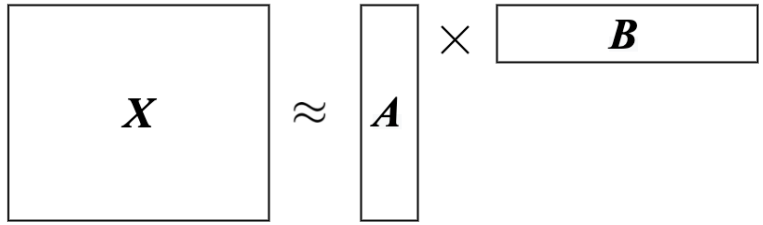
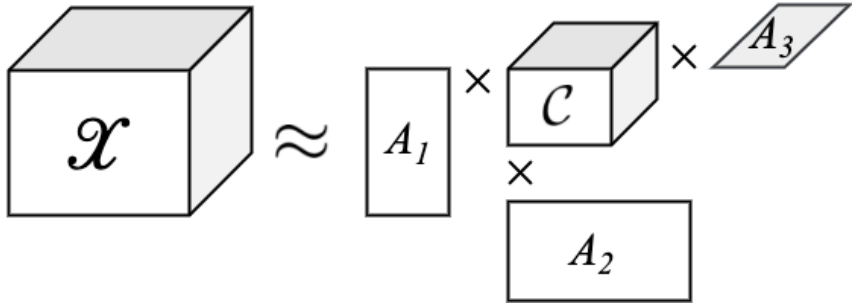
Matrix and Tensor Factorization

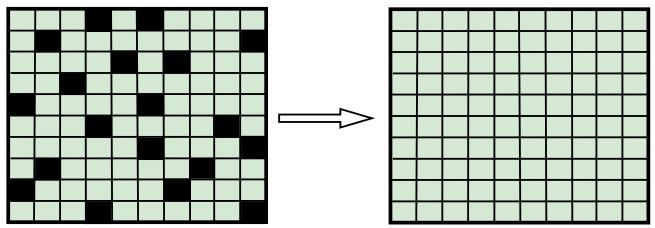
- Matrix factorization



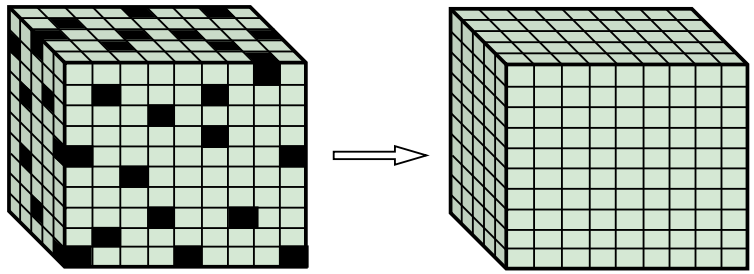
- Tensor factorization (CP, Tucker, etc)



- Matrix and tensor completion



Matrix Completion



Tensor Completion

Deep Matrix Factorization (DMF)

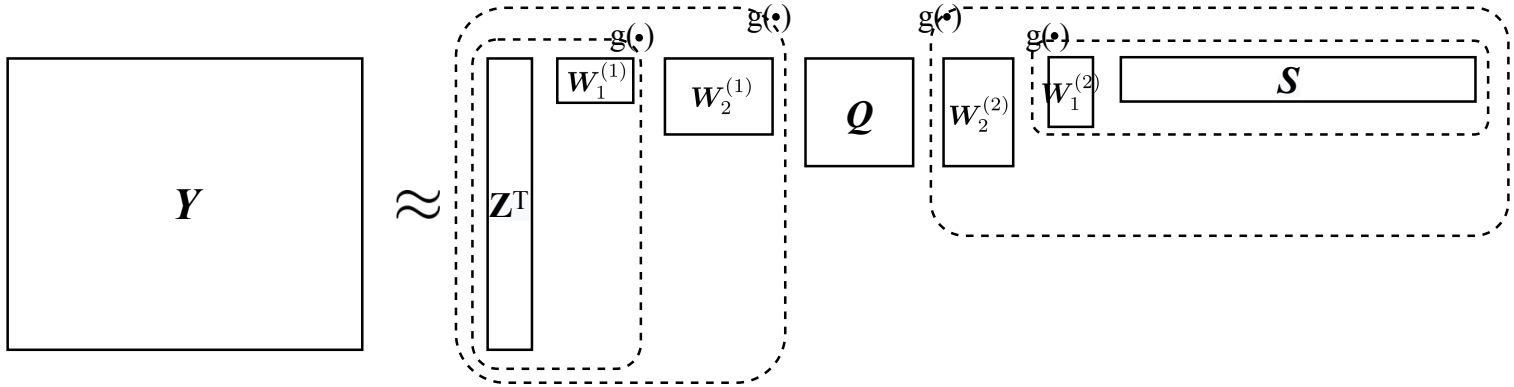
- A general formulation of DMF

$$\boldsymbol{X} \approx g_1(\boldsymbol{A}_1 g_2(\boldsymbol{A}_2 \cdots g_{L-1}(\boldsymbol{A}_{L-1}\boldsymbol{A}_L)\cdots)) \tag{1}$$

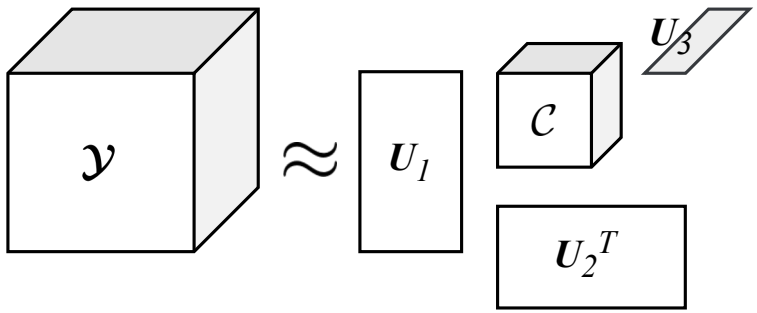
  - $\{g_l\}$ are activation functions
  - Deep Linear Matrix Factorization: linear $\{g_l\}$
    (Trigeorgis et al., 2016; Zhao et al., 2017; Arora et al., 2019)
  - Deep Nonlinear Matrix Factorization: nonlinear $\{g_l\}$
    (Xue et al., 2017; Wang et al., 2017; Fan & Cheng, 2018)
- DMF methods outperform shallow MF in many applications
- Limitations
  - DMF does not fully explore the nonlinearity of data
  - Deep nonlinear MF has no theoretical guarantee

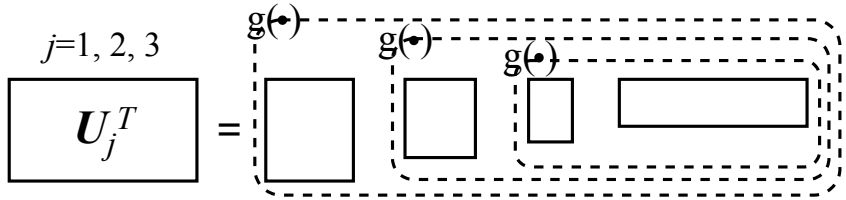
Multi-Mode Deep Matrix and Tensor Factorization (M^{2}DMTF)

- Two-mode matrix factorization



- Multi-mode tensor factorization

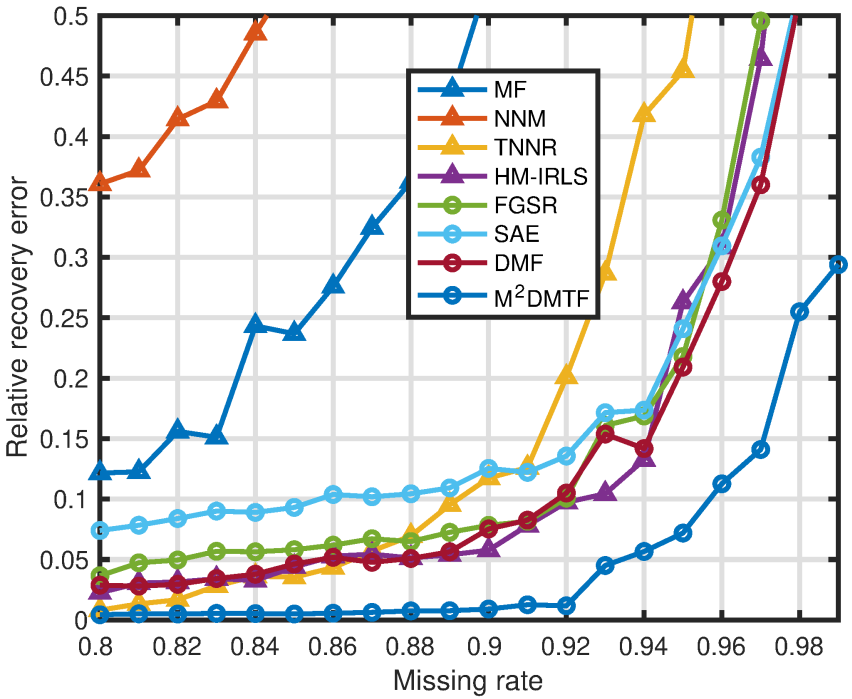


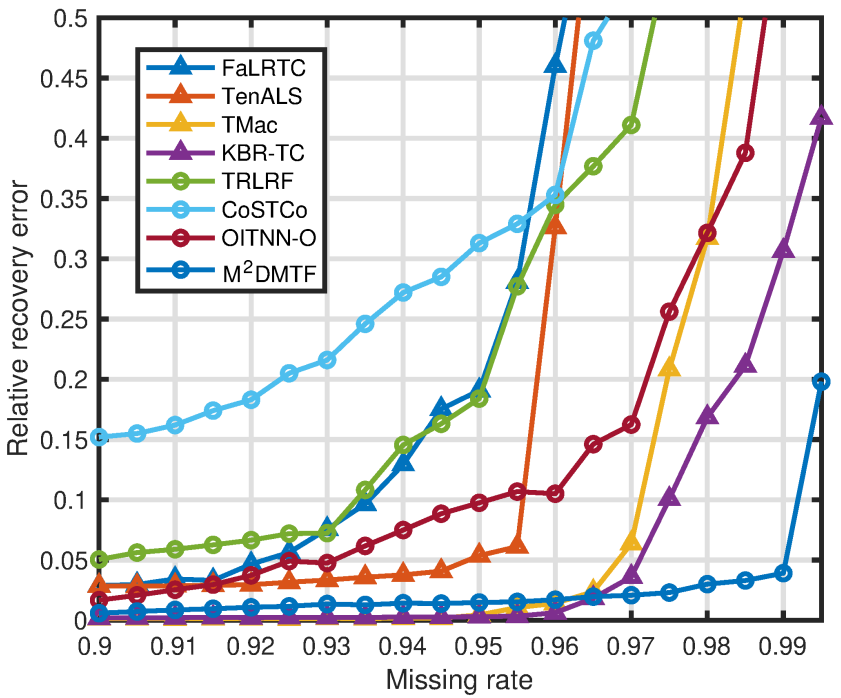


- Theoretical results
  - M^{2}DMTF have tighter generalization error bounds than classical MF, DMF, and TF in matrix and tensor completion

Numerical Results

- Matrix and tensor completion on synthetic data





Numerical Results

- Visualization of one slice of a real tensor (missing rate=0.97)