Kernelized Probabilistic Matrix Factorization

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Problem statement

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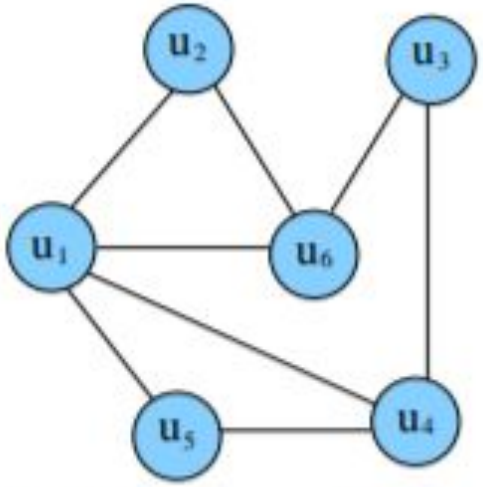
Matrix completetion problem

1. Recommendation systems
2. Image restoration



(a) Social network graph

	i_1	i_2	i_3	i_4
u_1	3	5	?	5
u_2	?	1	?	4
u_3	3	?	4	1
u_4	?	?	5	5
u_5	5	?	?	2
u_6	?	4	2	?

(b) Rating matrix

Methodology - Dataset

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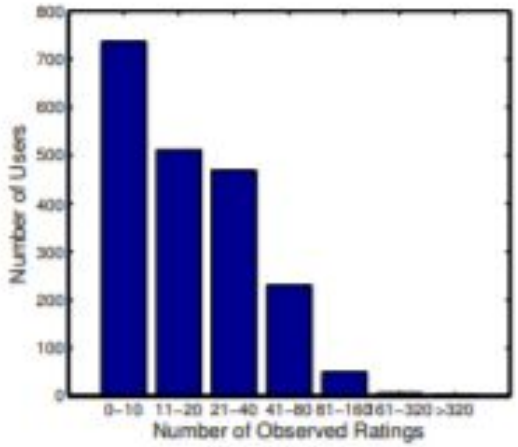
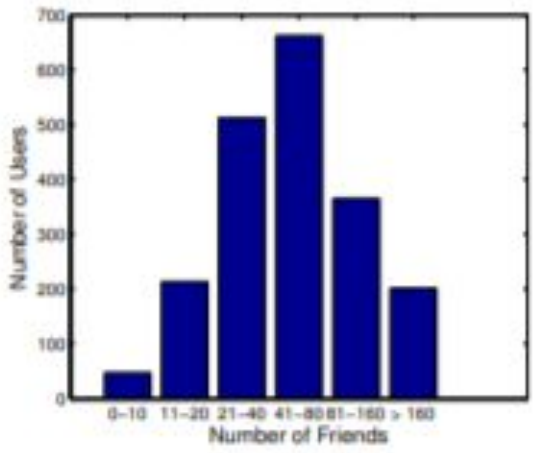
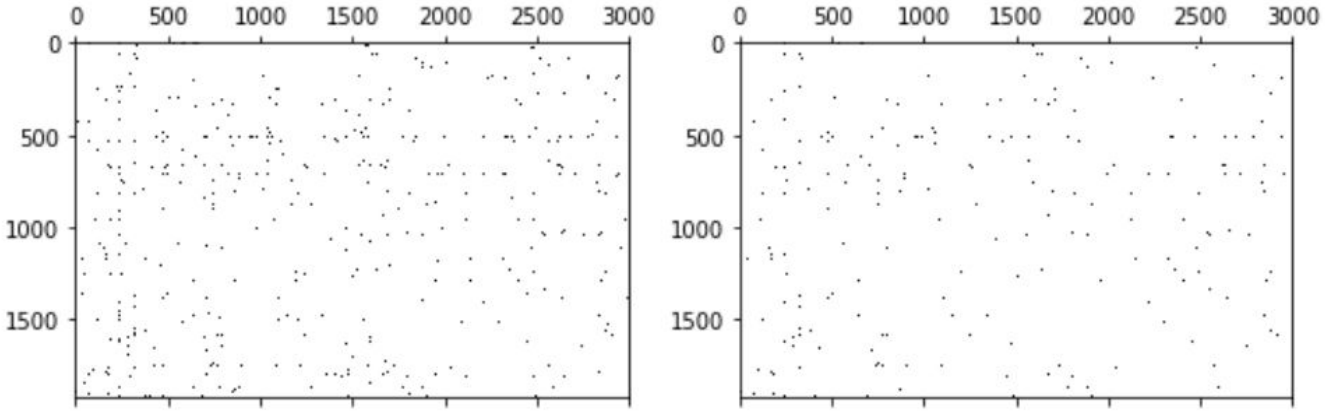
Dataset: Epinion

Number of Users	2 000
Number of Items	3 000
Number of Rating	60 485
Number of Relations	32 548
User-Item matrix density	1.01%

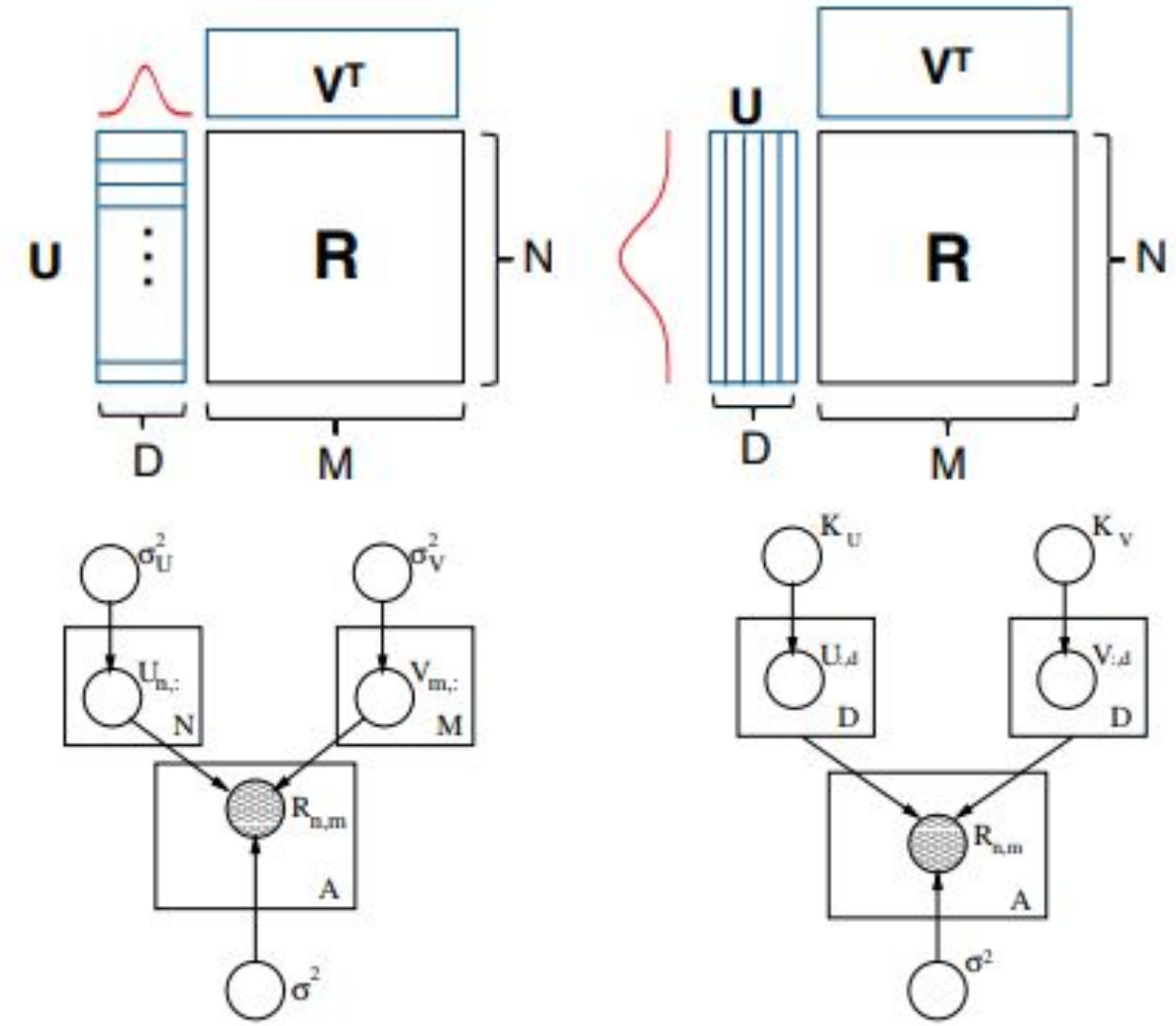




1. Get User-Item matrix (X_full)
2. Drop randomly 25% of its elements (X_trun)
3. Run decomposition on X_trun, trying to impute missing values => X_trun_imputed
4. RMSE(X_trun; X_trun_imputed)



Methodology - PMF vs KPMF



- PMF
  - U is sampled in a “row-wise” manner
  - independent latent v. for each row
- KPMF
  - U is sample in a “column-wise”
  - latent vectors spanning all rows
  - uses side information

KPMF: Maximize the log-posterior

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$$
\begin{aligned}
&\log p(U, V | R, \sigma^2, K_U, K_V) \\
&= -\frac{1}{2\sigma^2} \sum_{n=1}^{N} \sum_{m=1}^{M} \delta_{n,m} (R_{n,m} - U_{n,:} V_{m,:}^T)^2 \\
&\quad - \frac{1}{2} \sum_{d=1}^{D} U_{:,d}^T S_U U_{:,d} - \frac{1}{2} \sum_{d=1}^{D} V_{:,d}^T S_V V_{:,d} \\
&\quad - A \log \sigma^2 - \frac{D}{2} (\log |K_U| + \log |K_V|) + C,
\end{aligned}
$$

Methodology - Graph Kernels

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Define a similarity measure for users' taste

- Diffusion kernel

$$K_D = \lim_{n\to\infty}\left(1-\frac{\beta L}{n}\right)^n = e^{-\beta L},$$

- Regularized laplacian

$$K_{RL} = (I+\gamma L)^{-1},$$

Results

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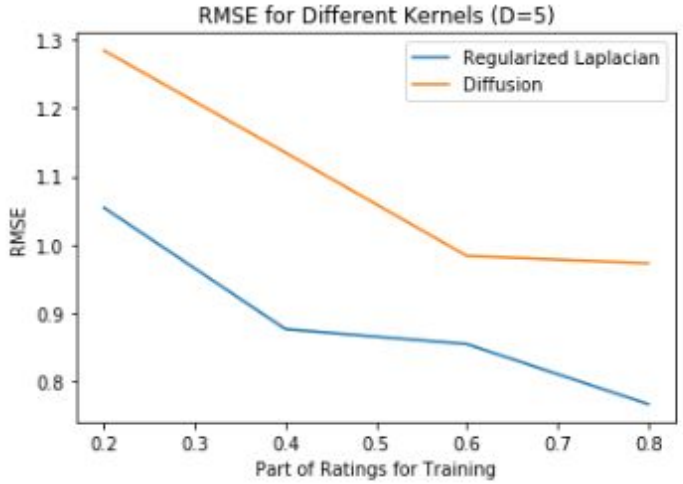

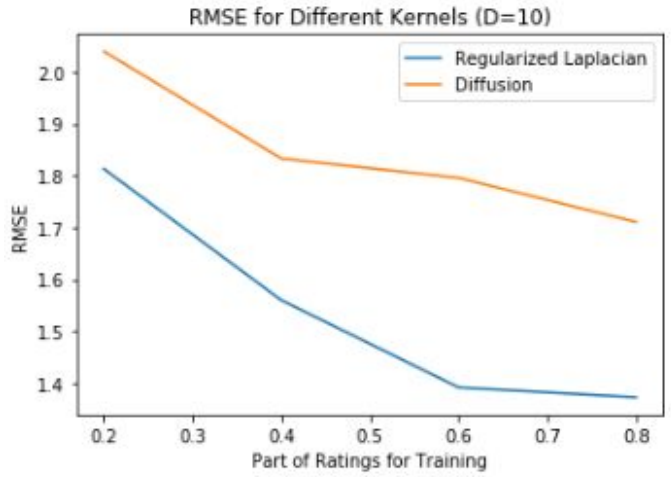

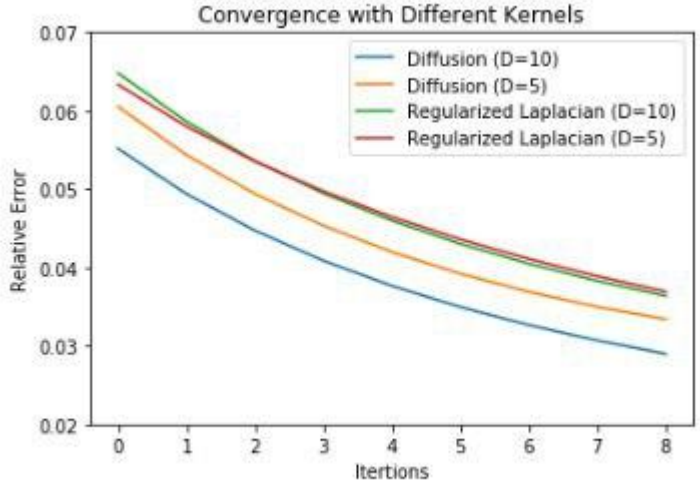

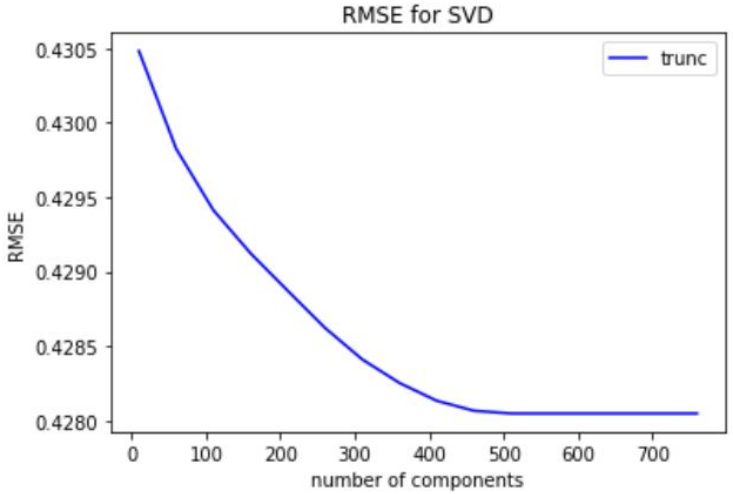

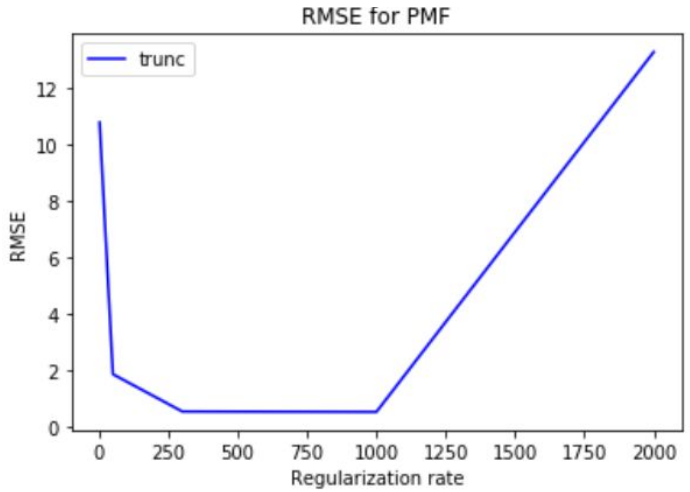

Model with top parameters	RMSE
KPMF (D = 5; Kernel = 'Regularized Laplacian') **(need more iteration!)**	0.763
PMF (regularization_rate = 300)	0.431
SVD (n_comp = 550)	0.423