Tutorial 11

Overview

Recommender Systems

Content-based Filtering

- Supervised learning method (features & labels)
  - Features can describe users (e.g. "average amount of time spent watching netflix") and/or items (e.g. "Romantic Comedy", "Oscar winning")
  - Labels are ratings
- Fit a model, then at test time recommend the item that would be rated the highest.

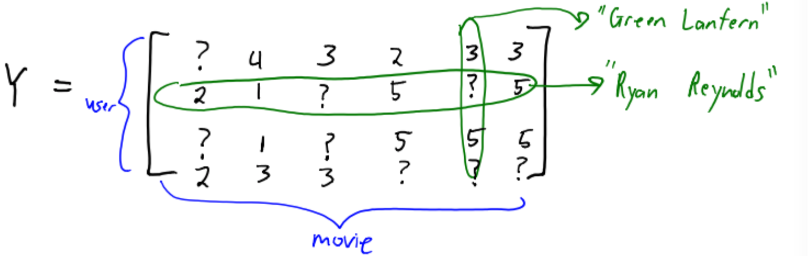
w_1 *


$+w_2*$

$\Rightarrow$


Collaborative Filtering

- Unsupervised learning
  - We are given users' ratings of items but no features of users or items
  - Need to fill in the "user-item matrix"



Collaborative Filtering - Latent Factor Model

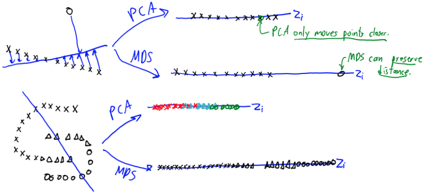
- Instead of prespecifying features like content-based filtering, we learn features to represent users and items
$$y_{ij} \approx w_j^T z_i$$
$$Y \approx Z_{n,k} W_{k,d}$$
- z_i feature vector for each user
- w_j feature vector for each movie
- Use a squared loss function with L2 regularization to train model over available ratings, R
$$F(Z,W) = \sum_{(i,j)\in R}(w_j^T z_i - y_{ij})^2 + \frac{\lambda_1}{2}\|Z\|_F^2 + \frac{\lambda_2}{2}\|W\|_F^2$$
- Can also introduce bias for user, item, or both
$$y_{ij} \approx w_j^T z_i + \beta + \beta_i + \beta_j$$

Multi-Dimensional Scaling

- No latent factors, directly optimize the location of the z_i values
- Classic MDS cost function:

$$f(Z) = \sum_{i+1}^{N} \sum_{j=i+i}^{N} (\|z_i - z_j\| - \|x_i - x_j\|)^2$$

- PCA used latent factors, W, and represented the data as a **linear** combination of them
- MDS is non-parametric



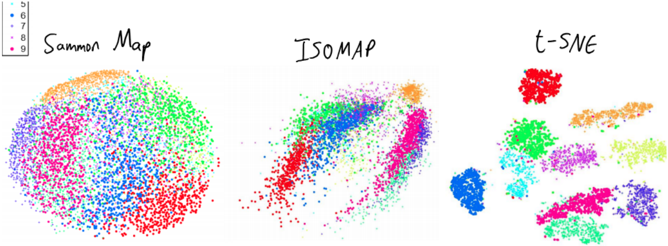
MDS Variants

- General MDS cost function:

$$f(Z) = \sum_{i+1}^{N} \sum_{j=i+i}^{N} d_3(d_1(z_i, z_j), d_2(x_i, x_j))$$

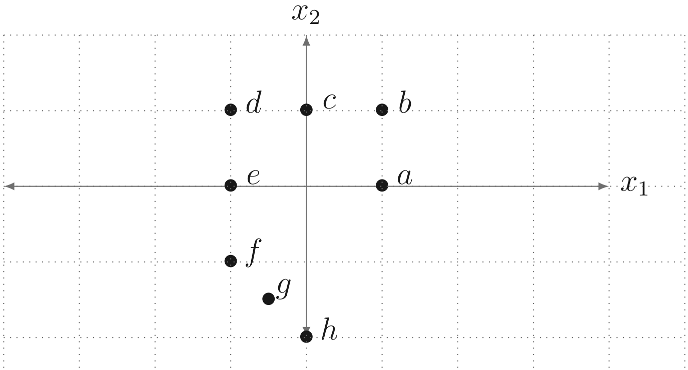
- $d(\cdot, \cdot)$ can be
  - A norm (classic MDS)
  - Geodesic distance (ISOMAP, d_2)
    - Distance along graph formed by k-nearest neighbours
- Sammon's Mapping

$$f(Z) = \sum_{i+1}^{N} \sum_{j=i+i}^{N} \frac{(d_1(z_i,z_j) - d_2(x_i,x_j))^2}{d_2(x_i,x_j)}$$



ISOMAP Exercise

Create a distance matrix using geodesic distances, where $k = 2$



ISOMAP Exercise - Answer

	a	b	c	d	e	f	g	h
a	0	1	$\sqrt{2}$	$\sqrt{2}+1$	$\sqrt{2}+2$	$\sqrt{2}+3$	$1.5\sqrt{2}+3$	$2\sqrt{2}+3$
b		0	1	2	3	4	$0.5\sqrt{2}+4$	$\sqrt{2}+4$
c			0	1	2	3	$0.5\sqrt{2}+3$	$\sqrt{2}+3$
d				0	1	2	$0.5\sqrt{2}+2$	$\sqrt{2}+2$
e					0	1	$0.5\sqrt{2}+1$	$\sqrt{2}+1$
f						0	$0.5\sqrt{2}$	$\sqrt{2}$
g							0	$0.5\sqrt{2}$
h								0