Recommender Systems
lecture 1: introduction

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Historical note

«What is recommender system?» evolution:

- In a typical recommender system people provide recommendations as inputs, which the system then aggregates and directs to appropriate recipients. In some cases the primary transformation is in the aggregation; in others the system's value lies in its ability to make good matches between the recommenders and those seeking recommendations.

  Resnick, P. and Varian, H. R.: 1997, 'Recommender Systems'. Communications of the ACM

- More formally, the recommendation problem can be formulated as follows: Let C be the set of all users and let S be the set of all possible items that can be recommended. Let u be a utility function that measures the usefulness of item s to user c, that is, u: C x S $\Rightarrow$ R, where R is a totally ordered set (for example, nonnegative integers or real numbers within a certain range). Then, for each user $c \in$ C, we want to choose such item $s' \in$ S that maximizes the user's utility.

  Adomavicius, G., and Tuzhilin, A. 2005. Toward the Next Generation of Recommender Systems: A Survey of the State-of-the-Art and Possible Extensions. IEEE Transactions on Knowledge and Data Engineering


Netflix Prize

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Leaderboard

Display top 20 leaders.

Rank	Team Name	Best Score	% Improvement	Last Submit Time
1	The Ensemble	0.8553	10.10	2009-07-26 18:38:22
2	BellKor's Pragmatic Chaos	0.8554	10.09	2009-07-26 18:18:28
Grand Prize - RMSE <= 0.8563				
3	Grand Prize Team	0.8571	9.91	2009-07-24 13:07:49
4	Opera Solutions and Vandelay United	0.8573	9.89	2009-07-25 20:05:52
5	Vandelay Industries !	0.8579	9.83	2009-07-26 02:49:53
6	PragmaticTheory	0.8582	9.80	2009-07-12 15:09:53
7	BellKor in BigChaos	0.8590	9.71	2009-07-26 12:57:25
8	Dace_	0.8603	9.58	2009-07-24 17:18:43
9	Opera Solutions	0.8611	9.49	2009-07-26 18:02:08
10	BellKor	0.8612	9.48	2009-07-26 17:19:11
11	BigChaos	0.8613	9.47	2009-06-23 23:06:52
12	Feeds2	0.8613	9.47	2009-07-24 20:06:46
Progress Prize 2008 - RMSE = 0.8616 - Winning Team: BellKor in BigChaos				
13	xiangliang	0.8633	9.26	2009-07-21 02:04:40
14	Gravity	0.8634	9.25	2009-07-26 15:58:34
15	Ces	0.8642	9.17	2009-07-25 17:42:38
16	Invisible Ideas	0.8644	9.14	2009-07-20 03:26:12
17	Just a guy in a garage	0.8650	9.08	2009-07-22 14:10:42
18	Craig Carmichael	0.8656	9.02	2009-07-25 16:00:54
19	J Dennis Su	0.8658	9.00	2009-03-11 09:41:54
20	acmehill	0.8659	8.99	2009-04-16 06:29:35
Progress Prize 2007 - RMSE = 0.8712 - Winning Team: KorBell				
Cinematch score on quiz subset - RMSE = 0.9514				

One of the first RecSys competitions

(02.10.2006 - 26.06.2009)

netflixprize.com/leaderboard

Motivation: business value

Amazon

- 35% of sales estimated to be generated from recommendation system
- billions of dollars in revenue generated through personalized product recommendations

Netflix

- 80% of content watched on Netflix is a result of recommendation
- "the combined effect of personalization and recommendations save us more than $1B per year".[a]

[a] https://www.businessinsider.com/netflix-recommendation-engine-worth-1-billion-per-year-2016-6

Motivation: users value

1. **Better discovery & diversity of recommendations:** broaden users' perspectives, encourage them to try new things, and create a more inclusive and diverse experience.
2. **Increased user engagement:** provide personalized and relevant experience for users to help users find what they're looking for and engage with the service.
3. **Better use of data:** provide insights into user behavior which helps businesses make more informed decisions.

connect listeners and creators in a unique and enriching way

Example mission (Spotify), from: https://www.youtube.com/watch?v=Ysh0CXUbXsU

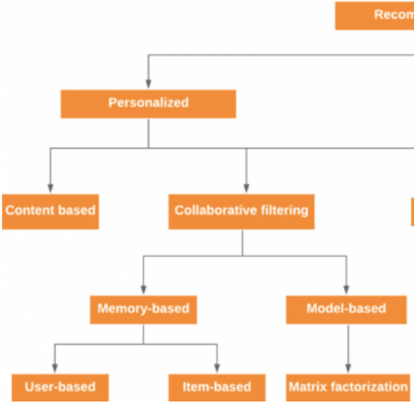


image credit: https://thingsolver.com/introduction-to-recommender-systems

Problem statement

Given:

- $U = \{u_j|, \ j \in 1, \dots n_{users}\}$ — set of users
- $I = \{i_j| \ , \ j \in 1, \dots n_{items}\}$ — set of items.
- $R = \|r_{ui}\|$ — relation matrix of shape $n_{users} \times n_{items}$,

$$r_{ui} \in \left[\begin{array}{c} \text{typically } \{0,1\}\text{— implicit feedback} \\ \text{typically } \{1,2,3,4,5\}\text{— explicit feedback} \end{array} \right.$$

Possible tasks:

Rating prediction

- Predict unknown r_{ui} — regression or (multi-class) classification

Top-k ranking

- Rank top-k recommendations for items — item2item
- Rank top-k recommendations for users — **item2user (course focus)**

Evaluation metrics (item2user)

1. **nDCG**

$$DCG@k(u) = \sum_{j=1}^{k} \frac{2^{r_{uj}} - 1}{\log_2(j+1)}$$

$$IDCG@k(u) = \max(DCG@k(u))$$

$$nDCG@k(u) = \frac{DCG@k(u)}{IDCG@k(u)}$$

$$nDCG@k = \frac{\sum_{u=1}^{n_{users}} nDCG@k(u)}{n_{users}}$$

2. **Mean Average Precision**

$$p@m(u) = \frac{\sum_{j=1}^{m} [r_{uj} > 0]}{m}$$

$$ap@k(u) = \frac{\sum_{j=1}^{k} [r_{uj} > 0] p@j(u)}{\min(k, |r_u|)}$$

$$MAP@k = \frac{\sum_{u=1}^{n_{users}} ap@k(u)}{n_{users}}$$

3. etc.

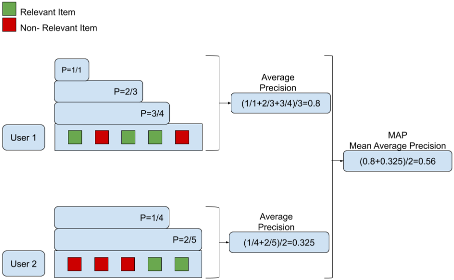
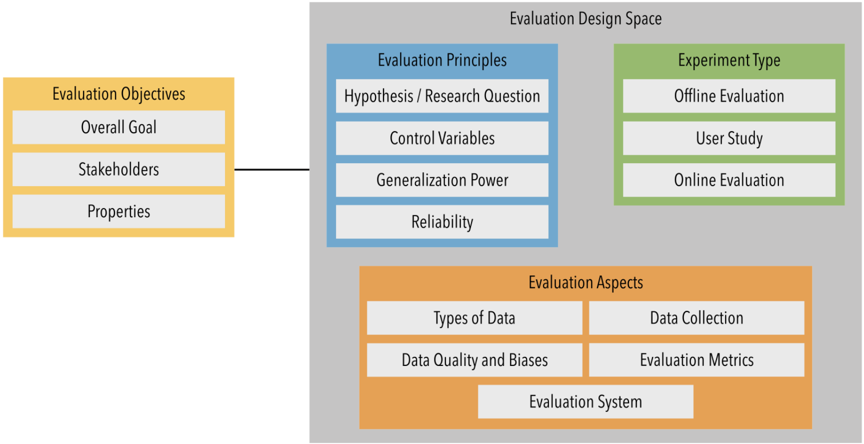


image credit:

https://medium.com/swlh/rank-aware-recsys-evaluation-metrics-5191bba16832

Overall evaluation



Evaluation framework example

image credit: https://dl.acm.org/doi/10.1145/3556536

Literature

1. *Charu C. Aggarwal.* (2016). Recommender Systems: The Textbook.
2. *F. Ricci, L. Rokach, B. Shapira.* (2011). Recommender Systems Handbook.
3. *Adomavicius, G., Tuzhilin, A.* (2005). Toward the next generation of recommender systems: A survey of the state-of-the-art and possible extensions. IEEE Transactions on Knowledge and Data Engineering, 17(6), 734-749.
4. *Eva Zangerle, Christine Bauer* (2022). Evaluating Recommender Systems: Survey and Framework. ACM Computing Surveys, Volume 55, Issue 8, Article No.: 170, pp 1–38