

# Introduction to Recommender Systems

Readings = Introductory Chapters from Ricci/Aggarwal

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# Summary

## 1 Overview of Recommender Systems

## 2 Practical Matters

# Overview of Recommender Systems

# Information Access Systems

1 Recommendation

2 Search

# Information Access Systems

- 1 Recommendation
- 2 Search

# Definitions 1

- "Recommender systems (RS) are software tools and techniques providing suggestions for items to be of use to a user" (Ricci, Rokach, & Shapira, 2011)

# Definitions 2

- Users: People who are interacting with items within a RS
- Items: The entities that are being recommended (e.g., products, articles, social media posts, other users to follow, etc.)
- Transactions: The ways in which users interact with items
  - Explicit feedback: Ratings of 1-5 stars, slider ratings, binary thumbs up/thumbs down, unary "likes", etc.)
  - Implicit feedback: Derived from user behavior. Examples include clicks, purchases, view time, returns, shares, etc. Note that there are often no negative examples.

# A Multi-stakeholder Problem

RS must account for multiple stakeholders who often have competing goals

- Users
- Content Providers
- Primary Service Providers
- Third-Party Service Providers



# User Goals

- Find some good items
- Find all of the relevant items
- Find a sequence of items that make sense (e.g., playlist)
- Find sets of items (e.g., complementary items)
- Find items that are good for a particular situation

# Primary Service Provider Goals

- Sell more items
- Sell more diverse items/promote items they want to get rid of
- Improve user satisfaction
- Increase user loyalty
- Improve understanding of the customer

# Third-Party Provider Goals

- Improve primary service provider loyalty
- Up-sell primary service providers on new services or products
- Collect data that can be packaged and sold as DaaS
- Collect data that can improve current or future algorithm performance
- Understand consumer behavior across multiple sites/platforms

# A Multi-stakeholder Research Problem

- Academics tend to focus on research relevant to users (including content providers as users)
- Industry tends to focus on users to some extent, but also on service providers to a large extent
- There is very little research that attempts to address more than one stakeholder at a time
- This is a problem

# Some Common Notation Stuff

- A user-item interaction matrix  $\mathbb{R}^{m \times n}$  is a matrix with  $m$  users and  $n$  items. We usually refer to the matrix as  $R$ .
- $R(u, i)$  represents user  $u$ 's actual rating for item  $i$
- $\hat{R}(u, i)$  represents a prediction for user  $u$ 's rating for item  $i$
- Most of the entries in  $R$  are empty because most users don't interact with most items (i.e., sparse data)

# The Matrix Need Not Be Scary

Figure: Examples of user-item matrices from Aggarwal

	GLADIATOR	GODFATHER	BEN-HUR	GOODFELLAS	SCARFACE	SPARTACUS
$U_1$	1			5		2
$U_2$		5			4	
$U_3$	5	3		1		
$U_4$			3			4
$U_5$				3	5	
$U_6$	5		4			

(a) Ordered ratings

	GLADIATOR	GODFATHER	BEN-HUR	GOODFELLAS	SCARFACE	SPARTACUS
$U_1$	1			1		1
$U_2$		1			1	
$U_3$	1	1		1		
$U_4$			1			1
$U_5$				1	1	
$U_6$	1		1			

(b) Unary ratings

# Types of RS Algorithms

- Content-based: Uses item meta-data
- Collaborative filtering: Uses patterns in the user-item matrix
- Knowledge-based: Uses domain knowledge to match users to item profiles
- Hybrid: Uses some combination of algorithms
- Lots of others

# What is a good recommendation/RS? #1

- Accuracy/Relevance: How well did the recommendation prediction for an item/list of items match the user's utility for an item/list of items?
  - Point-wise accuracy: For each individual item, how far off was the recommendation?
    - We predicted a user would rate Bodacious Bourbon 1.5 stars, and she rated it 2 stars. We were off by 0.5 stars.
  - List-wise accuracy: How well did we order the list of recommendations given the user's actual ordering?
    - We predicted the ranking would be 1. Stellar Scotch, 2. Righteous Rye, 3. Bodacious Bourbon and the user's actual preference orderings were 1. Righteous Rye, 2. Stellar Scotch, 3. Bodacious Bourbon
  - Can be measured offline (using historical data) or online (using A/B testing, etc.). These metrics don't always agree.



# What is a good recommendation/RS? #2

- Novelty: Did the RS algorithm recommend some stuff the user hasn't seen in the past?
- Serendipity: Did the user recommend some items that are a little unexpected, but still really useful for the user?
- Diversity: Within a given list of items, did the algorithm recommend products that were appropriately distinctive?
- Coverage: Did the algorithm recommend most of the available items to at least some of the users?
- Usability: Did the interfaces for the RS enable users to accomplish their goals?

# What is a good recommendation/RS? #3

- Fairness: No singular definition within RS or machine learning, generally
  - Did all content-providers get a fair shake at having their content be consumed (i.e., harms of allocation)?
  - Did the RS represent some users in a fashion that could be considered offensive and/or harmful (i.e., harms of representation)?
- Explainability: Can we tell the user on what basis we made this recommendation?

# What is a good recommendation/RS? 4

- Click-through rate: What proportion of the recommended items that the user saw did the user click on?
- Attributable sales: How many sales can we attribute to an item being recommended?
- Overall cart value: Did users who saw recommended items end up having higher checkout totals
- And many more!

# Discussion/QA

- Thoughts?
- Questions?

# Practical Matters

# Meeting Format

- Presentations with presenter
- Q & A with moderator
- Free-form discussion
- Something else?

# Meeting Frequency

- Bimonthly
- Monthly
- Something else?

# Discussion

- Is there anything else we need to talk about?



# References



Aggarwal, C. C. in *Recommender Systems: The Textbook* 1–28 (Springer, 2016).



Ricci, F., Rokach, L. & Shapira, B. in *Recommender Systems Handbook* 1–35 (Springer, 2011).

# The End