

# 1-4(a): Taxonomy of Recommender Systems (part 1 of 2)



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Introduction to Recommender Systems

## Learning Objectives

- To understand the different types of recommender systems
  - A framework for analyzing recommender systems in general
  - A specific overview of different recommendation algorithms
- To acquire a roadmap for the rest of the course, based on the algorithms studied

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## Analytical Framework

- Dimensions of Analysis
  - Domain
  - Purpose
  - Recommendation Context
  - Whose Opinions
  - Personalization Level
  - Privacy and Trustworthiness
  - Interfaces
  - Recommendation Algorithms

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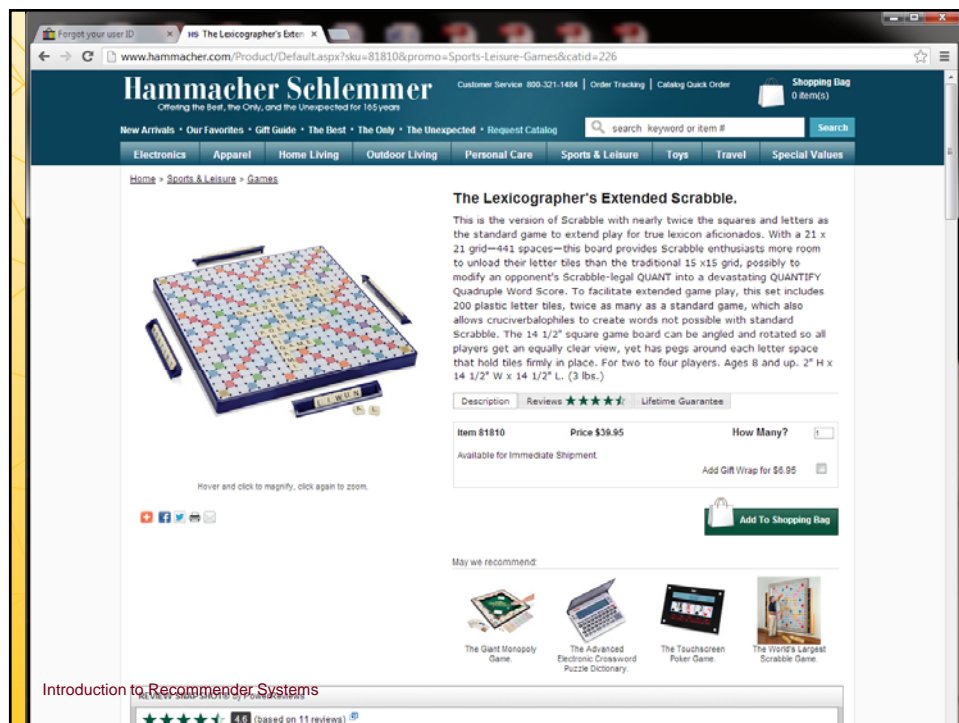
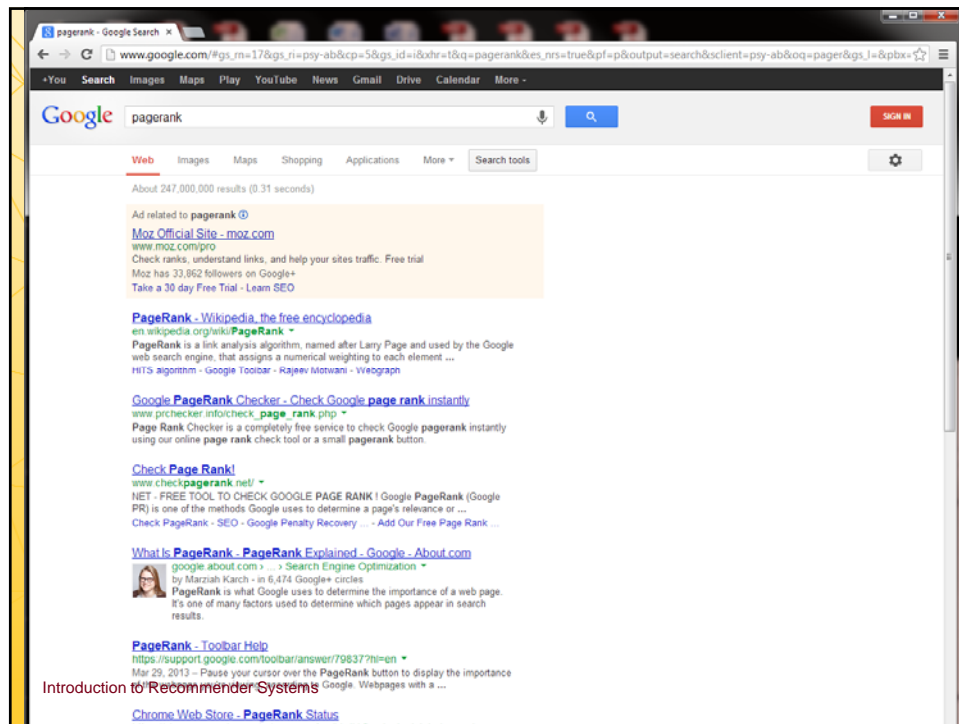


## Domains of Recommendation

- Content to Commerce and Beyond
  - News, information, “text”
  - Products, vendors, bundles
  - Matchmaking (other people)
  - Sequences (e.g., music playlists)
- One particularly interesting property
  - New items (e.g., movies, books, ...)
  - Re-recommend old ones (e.g., groceries, music)

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## Purposes of Recommendation

- The recommendations themselves
  - Sales
  - Information
- Education of user/customer
- Build a community of users/customers around products or content

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## OWL Tips

OWL Tips		
Date	9/30/98	
Word Commands	Comments	Priority
EditFind	Use Find more to search for text in file	88
EditDeleteWord	Learn the shortcut keys to delete words	87
FormatUnderline	Try using underlining for formatting text	80
FileClose	Try different ways to close your file	74
EditReplace	Use Replace more for finding and replacing text	72
ViewZoom	Learn how to enlarge or reduce the display	69
ViewShowAll	FYI-more than average use for Show All command	67
FormatBulletsAndNumbering	Learn how to automatically add bullets and numbering	64
ToolsWordCount	Use Word Count to look up statistics on files	61
ViewPage	Use Page Layout to view files before printing	57
User M06375      OWL Version 5.0c      OWL Help      OK		

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Las Vegas Hotels: Comparison

www.tripadvisor.com/Hotels-g45963-Las\_Vegas,Nevada-Hotels.html

Eleanor Steinman and Ramesh Jain are friends with reviewers of Mandarin Oriental, Las Vegas

**Mandarin Oriental, Las Vegas** ★★★★★  
Special Offer 2nd Night Free  
Ranked #1 of 271 hotels in Las Vegas  
1,798 reviews  
"a truly deserve 1st place!" 06/27/2013  
"oasis of tranquility" 06/27/2013  
Professional photos | Traveler photos (951) | Map  
Price Your Stay

Elizabeth Churchill and Dan Bodenheimer are friends with reviewers of Four Seasons Hotel Las Vegas

**Four Seasons Hotel Las Vegas** ★★★★★  
Special Offer USD 100 Hotel Credit  
Ranked #2 of 271 hotels in Las Vegas  
2,016 reviews  
"Superior Hotel on the Vegas Strip" 06/25/2013  
"Luxury in Sin City" 06/25/2013  
Professional photos | Traveler photos (948) | Map  
Price Your Stay

**Staybridge Suites Las Vegas** ★★★☆☆  
Special Offer Save on Hotel Packages!  
Ranked #3 of 271 hotels in Las Vegas  
431 reviews  
"Best hotel!" 06/25/2013  
"Very Nice Hotel off the strip" 06/25/2013  
Professional photos | Traveler photos (225) | Map  
Price Your Stay

**ARIA Sky Suites**  
Ranked #4 of 271 hotels in Las Vegas  
210 reviews  
"A unique thing of beauty" 06/25/2013  
"The Vegas Strip" 06/25/2013  
Traveler photos (121) | Map

3,600 Reviews  
30% off room rate

Comfort Inn Airport  
141 Reviews  
Free Breakfast and Wi-Fi  
View all Special Offers in Las Vegas

**Top picks in Las Vegas**

Bellagio Las Vegas  
5,701 Reviews  
Show Prices

Venetian Resort Hotel Casino  
8,954 Reviews  
Show Prices

Mandarin Oriental, Las Vegas  
1,798 Reviews  
Show Prices

**Friends' activity nearby**

The Strip  
Andrew Fetterer rated this attraction 4.5/5

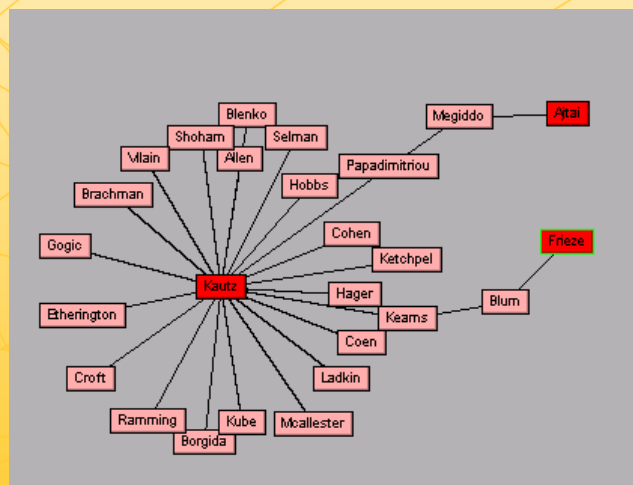
Springs Preserve  
J B Lawton III likes this attraction

Bellagio Fountains  
Andrew Fetterer rated this attraction 4.5/5

37 friends have been to Las Vegas & nearby towns

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## ReferralWeb

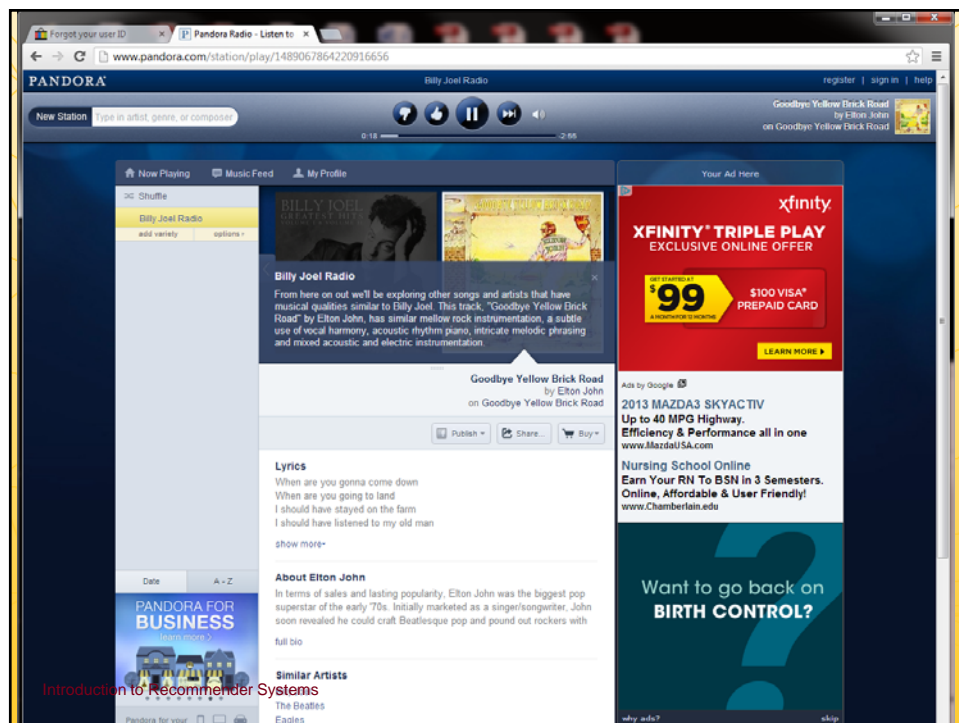


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## Recommendation Context

- What is the User doing at the time of recommendation?
  - Shopping
  - Listening to Music
  - Hanging out with other people
- How does the context constrain the recommender?
  - Groups, automatic consumption (vs. suggestion), level of attention, level of interruption?

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# Whose Opinion?

- “Experts”
- Ordinary “phoaks”
- People like you

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**wine.com - Cabernet Sauvignon, Rapel Valley, Chile - Microsoft Internet Explorer**

Address: [http://www1.wine.com/sku/wine\\_sku.jsp?sku=0031778](http://www1.wine.com/sku/wine_sku.jsp?sku=0031778)

**wine.com** Home Wine Shop Rare Wines Wine Clubs Gift Shop Corporate Gifts Accessory Shop Message Boards

Search:

**Wine Selector:**

Category  Price  Origin

**More Search Options**

**Short Cuts:**

- Red Wines
  - Cabernet
  - Merlot
  - Zinfandel
- White Wines
  - Chardonnay
  - Bubbly Wines
- Rare Wines
- What's New
- Samplers
- Specials
- Peter's Picks
- Band for the Buck
- Personalized Wine
- Wineries
- Wine Team

**Live Help**

Have a question for Customer Service? Use Live Help to get it answered immediately online. Monday-Sunday, 8 a.m. to 5 p.m. EST

**Casa Lapostolle**

**1997 Casa Lapostolle Cabernet Sauvignon, Rapel Valley, Chile**

Lapostolle's 1997 Cabernet Sauvignon is quite ripe and delicious, showing the soft tannins and easy-drinking profile needed to pair with everything from meatloaf to spaghetti and meatballs.

**\$9.95**

**Peter's Tasting Chart**

intensity	delicate	powerful
dry or sweet	bone dry	dessert
body	light body	very full body
acidity	soft, gentle	very crisp
tannin	none	heavy tannins
oak	none	heavy oak
complexity	direct	very complex

Casa Lapostolle, a partnership between French and Chilean winemaking families, is one of the newer wineries in Chile but they clearly know how to make fine wine. A red that rewards regular visits, Casa Lapostolle's 1997 Cabernet Sauvignon is so juicy, easy to drink, and affordable that you may want to buy it by the case. Ripe flavors of cassis and plum fruit are aligned within a delicate frame of oak and a silky, supple tannic finish that's perfect for everyday home-style comfort foods. The tannins are soft enough and the

**Our Wine Experts Recommend...**

**1997 Domaine Bascou Vin de Pays d'Oc (Cabernet Sauvignon), France**  
A thoroughly modern, international-style red.  
**\$9.95**

**1997 Meridian Cabernet Sauvignon, California**  
A mouthful of ripe black cherry fruit.  
**\$11.00**

**1998 Errazuriz Cabernet Sauvignon El Ciego Estate, Aconcagua Valley, Chile**  
A deliciously ripe and complex Cabernet Sauvignon.  
**\$8.95**

**Related Wines**

- Cabernet Sauvignon
- Casa Lapostolle
- Chile



**People Helping One Another Know Stuff**  
*Freq "Together, we know it all."* [Feedback](#)  
[Recency](#) [Top](#) [Area](#)  
[Posters](#) [Summary](#) [Help](#)

Search

\* Searches for posted web pages that contain any of the above words

Navigate Up: [PHOAKS Home Page](#) : [Newsgroup Areas](#) : [rec](#) . [music](#) . [dylan](#)

**Frequently Mentioned Resources**

Resource Title	Distinct Posters	Click on Bars for Message Context(s) *
1) <a href="#">Bob Dylan - Bob Links</a>	23	...
2) <a href="#">Bob Dylan Chords</a>	9	■■■■■
3) <a href="#">RemarQ - The Internet's Best Collaboration...</a>	8	■■■■■
4) <a href="#">bobydylan.com: Bob Dylan</a>	7	■■■■■
5) <a href="#">CDNOW</a>	6	■■■■■
6) <a href="#">Mailing List WWW Gateway</a>	6	■■■■■
7) <a href="#">Deja.com</a>	4	■■■■■
8) <a href="#">LC Z39.50 Server Soft Reference</a>	4	■■■■■
9) <a href="#">Resource at www.cs.umass.edu</a>	4	■■■■■
10) <a href="#">Sidewalk</a>	4	■■■■■

\* Note: each square represents the posting of one resource (e.g., URL) by one person. The lighter the square, the more recent the post. Click on a square to view messages where this resource was mentioned. Posting a web resource does not necessarily imply endorsing that resource. Sometimes it may actually mean the opposite. Consult the relevant netnews messages to obtain context.

## Personalization Level

- Generic / Non-Personalized
  - Everyone receives same recommendations
- Demographic
  - Matches a target group
- Ephemeral
  - Matches current activity
- Persistent
  - Matches long-term interests



**landsend.com - Microsoft Internet Explorer**

File Edit View Favorites Tools Help

Back Forward Stop Search Favorites History

Address

**LANDSEND** Shopping Bag Checkout My Account My Model Personal Shopper Ask Us

Welcome Women's Men's Kids' For the Home Luggage Gifts

1-800-963-4816

Lands' End Store  
Overstocks  
Corporate Sales

Search for  go

In All Products

Catalog Quick Order  
 go

Enter an Item Number

Sign up!  
• Subscribe to our e-mail newsletter  
• Request our Catalog  
• Join our Affiliate program

Special Services  
• Gift Certificates  
• Track your Order status

International Sites  
• Shop in your local language

Our Company  
• General Information  
• Investor's Corner

**It makes looking good look easy.**  
*The slimming Faille Tankini – just \$58!*  
**AS SEEN ON TV!**

The magic word is Faille (say it "file"). It's a revolutionary ribbed fabric that feels slimming and comfortable.

With a liberating – yet discreet – 2-piece style, our [Faille Tankini](#) works its magic at a very down-to-earth price: \$58.

Want a pile of faille? See [all of our slimming Faille favorites](#).

**Let Swim Finder locate your perfect suit!**

Quickly sorts through hundreds of Suits by:  
• Body Shape • Anxiety Zones • Leg Height • Bra Style • 18W-26W • Mastectomy • and more!

It's fast...it's fun! [Try Swim Finder today!](#) Or, to see new styles, swim separates, and more.

**Important Notice!**  
Lands' End has agreed to be acquired by Sears. Read the [announcement by Lands' End CEO David Dyer](#), and see the companies' [joint press release](#).

Lands' End Custom

Design your own pants right here:  
• [New! Men's Custom Jeans](#)  
• [Men's Custom Chinos](#)  
• [New! Women's Custom Jeans](#)  
• [Women's Custom Chinos](#)

**Subscribe!**  
News! Specials! Enter your e-mail address to subscribe:  
 go

**New! Lands' End Maternity**  
Internet Exclusive!  
[Purchase now!](#)

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http://www.landsend.com/cd/fp/prod0,,1\_2\_1930\_10433\_38642\_30064\_5-view=593,00.html?sid=620802

Unknown Zone

**B** **Brooks Brothers - Classically Modern Men's and Women's Apparel - Microsoft Internet Explorer**

File Edit View Favorites Tools Help

Back Forward Stop Search Favorites History

Address

productsearch  go shoppingbag

enter an item number or keyword to find your product

Welcome! Please [sign-in](#) or [register](#) with us and save \$10!

men women clearance specialtyshops

**Brooks Brothers**

light, luxurious **linen**  
**save 25%**  
on all men's and women's linen through 5.27  
[VIEW THE COLLECTION](#)

**THE GOLDEN FLEECE POLO**  
**NOW 3 FOR \$85**  
COMPARE & SAVE

**BECOME A MEMBER & SAVE**  
faster and easier shopping plus \$10 OFF  
[REGISTER TODAY](#)

**MEN'S & WOMEN'S CLEARANCE**  
**UP TO 80% OFF**  
BEGIN SAVING

brooks.buys gifts top ten boys brooks.mail about us 1.800.556.7039

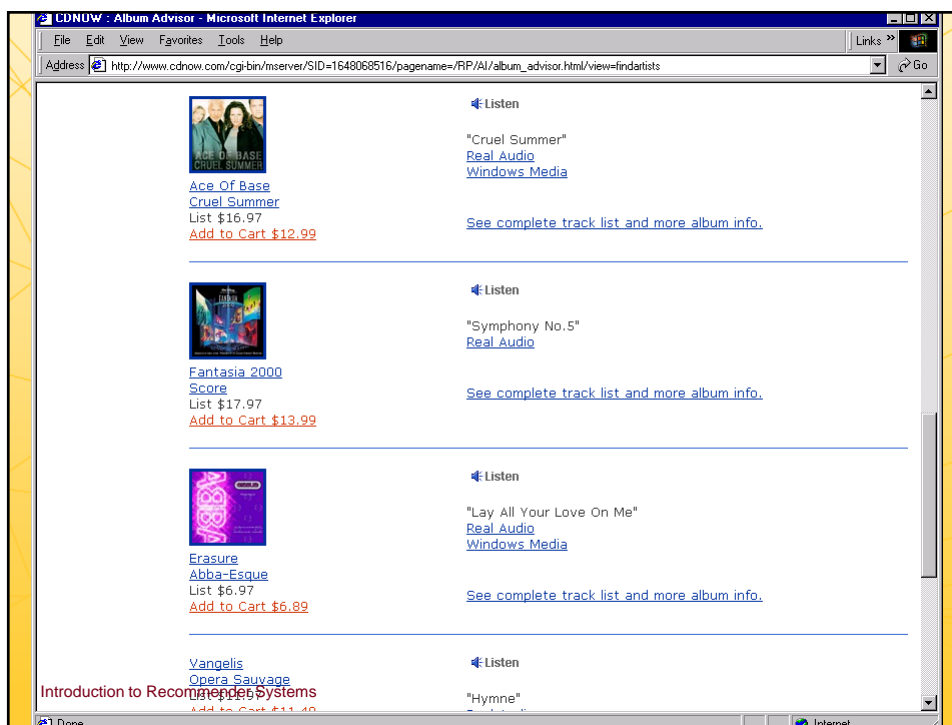
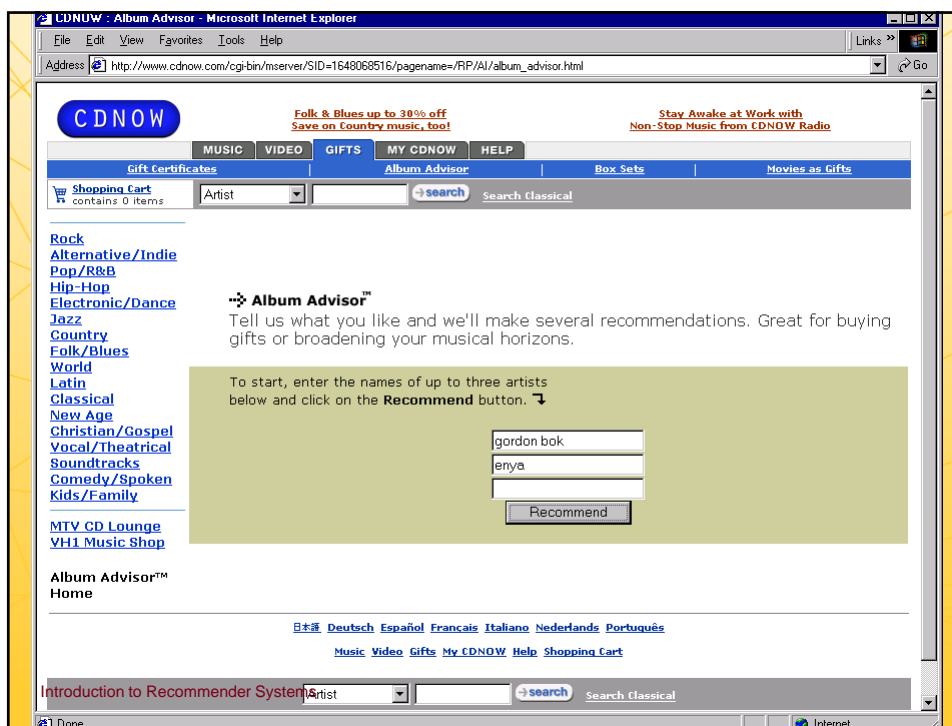
emailsignup  submit stores catalog brooks card privacy help members | sign-in

https://www.brooksbrothers.com/dynaset.asp?html=members&secure=yes

Internet

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## Privacy and Trustworthiness

- Who knows what about me?
  - Personal information revealed
  - Identity
  - Deniability of preferences
- Is the recommendation honest?
  - Biases built-in by operator
    - “business rules”
  - Vulnerability to external manipulation
  - Transparency of “recommenders”; Reputation

## Interfaces

- Types of Output
  - Predictions
  - Recommendations
  - Filtering
  - *Organic vs. explicit presentation*
    - Agent/Discussion Interface
- Types of Input
  - Explicit
  - Implicit

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## Recommendation Algorithms

- Non-Personalized Summary Statistics
- Content-Based Filtering
  - Information Filtering
  - Knowledge-Based
- Collaborative Filtering
  - User-User
  - Item-Item
  - Dimensionality Reduction
- Others
  - Critique / Interview Based Recommendations
  - Hybrid Techniques

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## 1-4(b): Taxonomy of Recommender Systems (part 2 of 2)



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## Recommendation Algorithms

- Non-Personalized Summary Statistics
- Content-Based Filtering
  - Information Filtering
  - Knowledge-Based
- Collaborative Filtering
  - User-User
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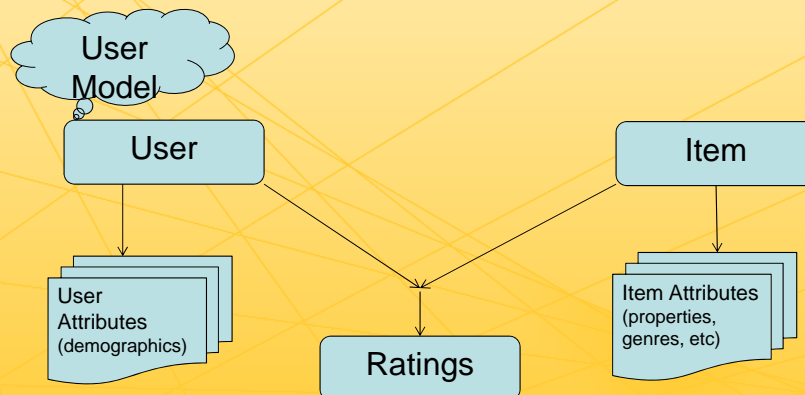
## From the Abstract to the Specific

- Basic Model
  - Users
  - Items
  - Ratings
  - (Community)

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## Linking these together



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## Non-Personalized Summary Stats

- External Community Data
  - Best-seller; Most popular; Trending Hot
- Summary of Community Ratings
  - Best-liked
- Examples
  - Zagat restaurant ratings
  - Billboard music rankings
  - TripAdvisor hotel ratings

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## Content-Based Filtering

- User Ratings x Item Attributes  $\Rightarrow$  Model
- Model applied to new items via attributes
- Alternative: knowledge-based
  - Item attributes form model of item space
    - Users navigate/browse that space
- Examples
  - Personalized news feeds
  - Artist or Genre music feeds

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## Personalized Collaborative Filtering

- Use opinions of others to predict/recommend
- User model – set of ratings
- Item model – set of ratings
- Common core: sparse matrix of ratings
  - Fill in missing values (predict)
  - Select promising cells (recommend)
- Several different techniques

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## Collaborative Filtering Techniques

- User-user
  - Select neighborhood of similar-taste people
    - Variant: select people you know/trust
  - Use their opinions
- Item-item
  - Pre-compute similarity among items via ratings
  - Use own ratings to triangulate for recommendations
- Dimensionality reduction
  - Intuition: taste yields a lower-dimensionality matrix
  - Compress and use a taste representation

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## Note on Evaluation

- To properly understand relative merits of each approach, we will spend significant time on evaluation
  - Accuracy of predictions
  - Usefulness of recommendations
    - Correctness
    - Non-obviousness
    - Diversity
  - Computational performance

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## Other Approaches

- Interactive recommenders
  - Critique-based, dialog-based
- Hybrids of various techniques

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## Moving Forward

- Next Lecture: A Tour of Amazon.Com, organized by our taxonomy
- Then, you should be able to:
  - Analyze a recommender application on your own
- Course Structure:
  - We step through the recommendation algorithms, with six major modules
  - Related topics intermingled

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