Recommender Systems: The Power of Personalization



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A Bit of History



- Ants, Cavemen, and Early Recommender Systems
 - The emergence of critics
- Information Retrieval and Filtering
- Manual Collaborative Filtering
- Automated Collaborative Filtering
- The Commercial Era



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Information Retrieval

- Static content base
 - Invest time in indexing content
- Dynamic information need
 - Queries presented in "real time"
- Common approach: TFIDF
 term frequency inverse document frequency
 - Rank documents by term overlap
 - Rank terms by frequency





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 - For Consortia Administrators

Announcements

- Information Systems Category Editor Needed for Computing Reviews
 Computing Reviews, the post-publication review and comment journal of
 ACM, is seeking a volunteer interested in serving as a category editor in the
 information systems area. Please see the Information Systems Category
 Editor search page for more information.
- New Journal: ACM Transactions on Interactive Intelligent Systems
 <u>ACM Transactions on Interactive Intelligent Systems (TiiS)</u> publishes
 research on the design, realization, or evaluation of interactive systems that
 incorporate some form of machine intelligence. Applications include user
 interface technologies; recommender systems and information retrieval;
 automated usability testing; human-robot interaction; semantic
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Information Filtering

- Reverse assumptions from IR
 - Static information need
 - Dynamic content base
- Invest effort in modeling user need
 - Hand-created "profile"
 - Machine learned profile
 - Feedback/updates
- Pass new content through filters



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Collaborative Filtering



- Premise
 - Information needs more complex than keywords or topics: quality and taste
- Small Community: Manual
 - Tapestry database of content & comments
 - Active CF easy mechanisms for forwarding content to relevant readers



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Automated CF

- The GroupLens Project (CSCW '94) •
 - ACF for Usenet News
 - users rate items
 - users are correlated with other users
 - personal predictions for unrated items
 - Nearest-Neighbor Approach
 - find people with history of agreement
 - assume stable tastes



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Does it Work?



- Yes: The numbers don't lie!
 - Usenet trial: rating/prediction correlation
 - rec.humor: 0.62 (personalized) vs. 0.49 (avg.)
 - comp.os.linux.system: 0.55 (pers.) vs. 0.41 (avg.)
 - rec.food.recipes: 0.33 (pers.) vs. 0.05 (avg.)
 - Significantly more accurate than predicting average or modal rating.
 - Higher accuracy when partitioned by newsgroup



It Works Meaningfully Well!

- Relationship with User Behavior •
 - Twice as likely to read 4/5 than 1/2/3
- Users *Like* GroupLens ٠
 - Some users stayed 12 months after the trial!



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"Perfect book, perfect subject, perfect writer. Dream Team is one of the best sports books I have ever read—a riveting inside look at a once-ina-lifetime squad at a once-in-a-lifetime moment in time. Jack McCallum has pieced together a masterpiece."—Jeff Pearlman, New York Times

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"Jack McCallum is one of my favorite writers on the NBA. If Jack writes it, even if I know the story, I want to read it. He reflects the best of his longtime residence in the glory days of *Sports Illustrated*: You can see the event, but you still want to know what the reporter has to say about it. *Dream Team* is a wonderful look back at what will live on not only as one of the NBA's great times but as a summary of its golden era. Jack beautifully blends what happened then with where-are-they-now? anecdotes, taking you behind the locker-room door with the greatest names of their era. This is such a wonderful read, you can't help but smiling."—Sam Smith, *New York Times* bestselling author of *The Jordan Rules*

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4.3 out of 5 stars		" Dream Team by Jack McCallum is the story of the American men's basketball team that swept through the 1992 Olympics in a successful quest to obtain gold medals."		^	
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By Barry Sparks VINE™ VOICE Format: Hardcover | Amazon Vine™ Review (What's this?)

The 1992 USA Olympic basketball team was dubbed "Dream Team." And, why not? The team featured the golden trio of Michael Jordan (perhaps the most famous person in the world at the time), Magic Johnson and Larry Bird as well as Patrick Ewing, Charles Barkley, David Robinson, John Stockton, Karl Malone, Clyde Drexler, Chris Mullin, Scottie Pippen and Christian Laettner (the only college player). Chuck Daly was the coach. Author Jack McCallum describes the team as "a collection of immortals gathered in one place at one time."

The 1992 Olympics in Barcelona marked the first time professional athletes could compete. The challenge, however, was to convince the NBA's best players to sacrifice their summer, compete as a team and to do it essentially for free.

McCallum, who covered the NBA and the Dream Team for Sports Illustrated, details how the Dream Team was selected and profiles each player He also writes about the efforts to keep Isiah Thomas off the team. Jordan, who wielded immense power, despised Thomas and didn't want him on the team. And, it was more important to make Jordan happy than any thing else. Even though Thomas was the best player on the Detroit Pistons, who had won back-to-back NBA championships, he was not a Dream Team member.

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Recommenders

- Tools to help identify worthwhile stuff
 - Filtering interfaces
 - E-mail filters, clipping services
 - Recommendation interfaces
 - Suggestion lists, "top-n," offers and promotions
 - Prediction interfaces
 - Evaluate candidates, predicted ratings



Historical Challenges

- Collecting Opinion and Experience Data •
- Finding the Relevant Data for a Purpose ٠
- Presenting the Data in a Useful Way •







Recommender Application Space



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Scope of Recommenders

- Purely Editorial Recommenders •
- **Content Filtering Recommenders** •
- Collaborative Filtering Recommenders •
- Hybrid Recommenders •





Recommender Application Space

- Dimensions of Analysis
 - Domain
 - Purpose
 - Whose Opinion
 - Personalization Level
 - Privacy and Trustworthiness
 - Interfaces
 - <Algorithms Inside>





Domains of Recommendation

- Content to Commerce •
 - News, information, "text"
 - Products, vendors, bundles



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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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Whose Opinion?

- "Experts"
- Ordinary "phoaks"
- People like you



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Personalization Level

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











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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



Interfaces

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



Wide Range of Algorithms

- Simple Keyword Vector Matches
- Pure Nearest-Neighbor Collaborative Filtering
- Machine Learning on Content or Ratings



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Collaborative Filtering: Techniques and Issues





Collaborative Filtering Algorithms

Non-Personalized Summary Statistics

- K-Nearest Neighbor
- Dimensionality Reduction
- Content + Collaborative Filtering
- Graph Techniques
- Clustering
- Classifier Learning





Teaming Up to Find Cheap Travel

- Expedia.com ۲
 - "data it gathers anyway"
 - (Mostly) no cost to helper
 - Valuable information that is otherwise hard to acquire
 - Little processing, lots of collaboration



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Within 1 Mile 💌	Food Decor Service Cost	Cuisine:	
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Hotels	"For real Japanese food, this is the place to be in the Netherlands" say fans	Pijp	
Attractions Submit	of this "absolute treat" in the Pijp's Hotel Okura that serves "fresh", "fabulous presentations" of "some of the best sushi in Europe" along with other "outstanding" offerings, all backed up by an "extensive sake list", "alas"	Website: www.okura.nl	
	some say, it's a "shame the decor doesn't quite meet the same level", but "excellent service" from the "trilingual staff" more than compensates – "be prepared" for the bill, though, as it's definitely "costly."	Payment: Accepts Major Credit Cards	
VOTE AT ZAGAT Vote in the New York City		Hours: Mon: - 9:30PM Tues: - 9:30PM VVed: - 9:30PM	
Restaurants Survey and get a FREE guide! Vote Now ►	Share Your Reviews With Other Zagat.com Users! Rate each category on a scale of 0-3 and add your review, or see review instructions. Submissions that do not follow our community guidelineswill not be	Fri: - 9:30PM Sat: - 9:30PM Sun: - 9:30PM	
	posted. Your review will also be your official contribution to Zagat Survey's official Rating and Review of the establishment	Operations: Full Bar Year Opened: 1971	
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Zagat: Is Non-Personalized Good Enough?

- What happened to my favorite guide? ٠
 - They let you rate the restaurants!
- What should be done? ۲
 - Personalized guides, from the people who "know good restaurants!"





Collaborative Filtering Algorithms

- Non-Personalized Summary Statistics
- K-Nearest Neighbor
 - user-user
 - item-item
- Dimensionality Reduction
- Content + Collaborative Filtering
- Graph Techniques
- Clustering
- Classifier Learning



CF Classic: K-Nearest Neighbor User-User



CF Classic: Submit Ratings



CF Classic: Store Ratings



CF Classic: Compute Correlations



CF Classic: Request Recommendations



CF Classic: Identify Neighbors



CF Classic: Select Items; Predict Ratings



	Hoop Dreams	Star Wars	Pretty Woman	Titanic	Blimp	Rocky XV
Joe	D	A	В	D	?	?
John	A	F	D		F	
Susan	A	A	А	А	A	А
Pat	D	Α		С		
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	Hoop Dreams	Star Wars	Pretty Woman	Titanic	Blimp	Rocky XV
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John	Ā	F	D		F	
Susan	A	A	А	А	А	A
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	Hoop Dreams	Star Wars	Pretty Woman	Titanic	Blimp	Rocky XV
Joe		Α	B	D	?	?
John	A	F	D		F	
Susan	А	А	А	А	A	А
Pat	D	Α		С		
Jean	Α	С	A	С		Α
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A Challenge: Sparsity



- Many E-commerce and content applications have many ۲ more customers than products
- Many customers have no relationship ٠
- Most products have some relationship ullet







- Have skim milk? Want whole milk too?
- Increases apparent sparsity
- Results in poor quality











Item-Item Matrix Formulation



Advancing Computing as a Science & Profession

Item-Item Discussion



- Good quality, in sparse situations
- Promising for incremental model building
 - Small quality degradation
 - Nature of recommendations changes
 - Big performance gain





Collaborative Filtering Algorithms

- Non-Personalized Summary Statistics
- K-Nearest Neighbor
- Dimensionality Reduction
 - Singular Value Decomposition
 - Factor Analysis
- Content + Collaborative Filtering
- Graph Techniques
- Clustering
- Classifier Learning





Dimensionality Reduction

- Latent Semantic Indexing
 - Used by the IR community
 - Worked well with the vector space model
 - Used Singular Value Decomposition (SVD)
- Main Idea
 - Term-document matching in feature space
 - Captures latent association
 - Reduced space is less noisy





The reconstructed matrix $R_k = U_k S_k V_k$ ' is the closest *rank-k* matrix to the original matrix *R*.



SVD: Mathematical Background

SVD for Collaborative Filtering 1. Low dimensional representation O(m+n) storage requirement $k \ge n$ 2. Direct $m \ge k$ Prediction $m \ge n$



Singular Value Decomposition

Reduce dimensionality of problem

- Results in small, fast model
- Richer Neighbor Network

Incremental Update

- Folding in
- Model Update

Trend

Towards use of probabilistic LSI





Collaborative Filtering Algorithms

- Non-Personalized Summary Statistics
- K-Nearest Neighbor
- Dimensionality Reduction
- Content + Collaborative Filtering
- Graph Techniques
 - Horting: Navigate Similarity Graph
- Clustering
- Classifier Learning
 - Rule-Induction Learning
 - Bayesian Belief Networks





- Survey Articles
 - Recommender Systems: From Algorithms to User Experience (2012): <u>http://www.grouplens.org/node/480</u>

Resources

- Collaborative Filtering Recommender Systems (2011): <u>http://www.grouplens.org/node/475</u>
- Books
 - Recommender Systems: An Introduction (2010) buy Jannach et al.
 - Recommender Systems Handbook (2010) by Ricci et al.
- Software Tools
 - LensKit <u>http://lenskit.grouplens.org</u>
 - MyMedia <u>http://www.mymediaproject.org</u>
 - Mahout http://mahout.apache.org



ACM: The Learning Continues



ACM Learning Center: http://learning.acm.org

- ACM SIGCHI: <u>http://www.sigchi.org</u>
- ACM Conference on Recommender Systems
 <u>http://recsys.acm.org</u>

