

An Introduction to Recommendation Systems

Agenda

- What is a Recommendation System?
- Recommendation Techniques
 1. Collaborative filtering
 2. Content-based filtering
- Tutorial using the MovieLens database
- Evaluation of Recommendation Systems
- Implicit vs. Explicit Feedback

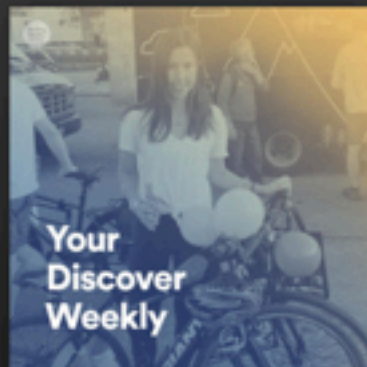
What is a recommendation system?

- An application of machine learning
- Predicts user preference, filters relevant content
- Clustering similar items and users together



Spotify

“Discover Weekly”



MADE FOR JILL

Discover Weekly

Your weekly mixtape of fresh music. Enjoy new discoveries and deep cuts chosen just for you. Updated every Monday, so save your...

Made for Jill Cts by Spotify • 30 songs, 1 hr 47 min

PLAY

FOLLOWING

...

Q Filter

Download ☐

	TITLE	ARTIST	
+	The Weekend - Funk Wav Remix	SZA, Calvin H...	3 days ago
+	You Say	Ehrling	3 days ago
+	Grow Up	Bolier	3 days ago



Amazon

“Frequently bought together”

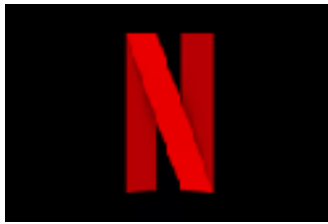
Customers who bought this item also bought

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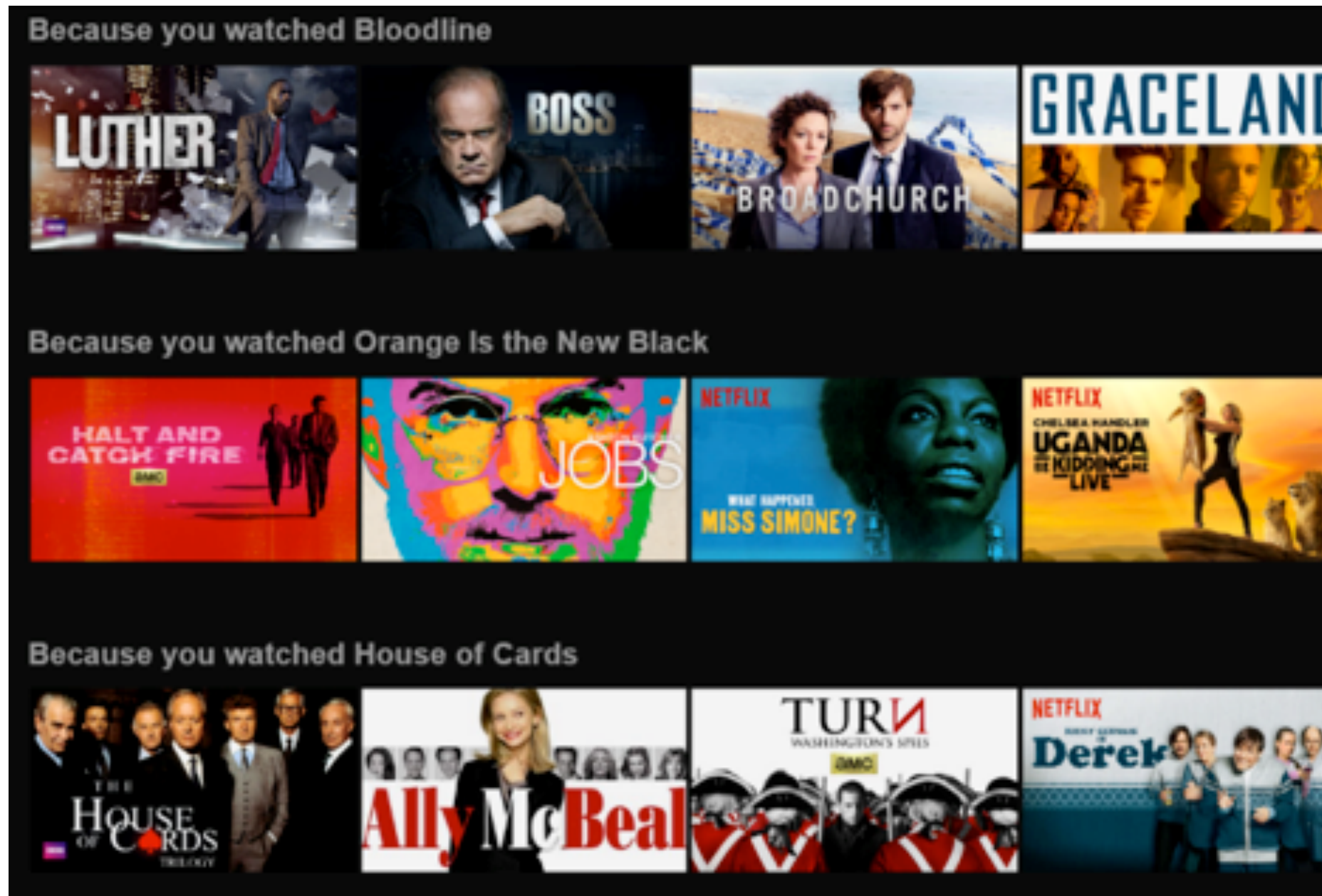
					
An Introduction to Statistical Learning: with Applications in R Gareth James ★★★★★ 13 Hardcover CDN\$ 77.35 ✓prime	Deep Learning Ian Goodfellow ★★★★★ 26 Hardcover CDN\$ 81.36	Applied Predictive Modeling Max Kuhn ★★★★★ 8 Hardcover CDN\$ 97.10 ✓prime	Pattern Recognition and Machine Learning Christopher M. Bishop ★★★★★ 8 Hardcover CDN\$ 85.14 ✓prime	Machine Learning: A Probabilistic Perspective Kevin P. Murphy ★★★★★ 6 Hardcover CDN\$ 120.49 ✓prime	Hands-On Machine Learning with Scikit-Learn and TensorFlow... Aurélien Géron ★★★★★ 27 Paperback CDN\$ 45.06 ✓prime





Netflix

“Because you watched this TV Show...”





OkCupid

“Finding your best match”

✓

2

3

Answer 7 questions to calculate your best matches.

Skip >

1 of 7

Are you a morning person?

⌂ Next Question

No

Yes



Twitter

“Who to follow”

Who to follow



Hillary Clinton ✓

@HillaryClinton

Wife, mom, grandma, women+kids advocate, FLOTUS, Senator, SecState, hair icon, pantsuit aficionado, 2016 presidential candidate.

Follow



Barack Obama ✓

@BarackObama

Dad, husband, President, citizen.

Follow



Ellen DeGeneres ✓

@TheEllenShow

Comedian, talk show host and ice road trucker. My tweets are real, and they're spectacular.

Follow

Recommendation Systems = Machine Learning

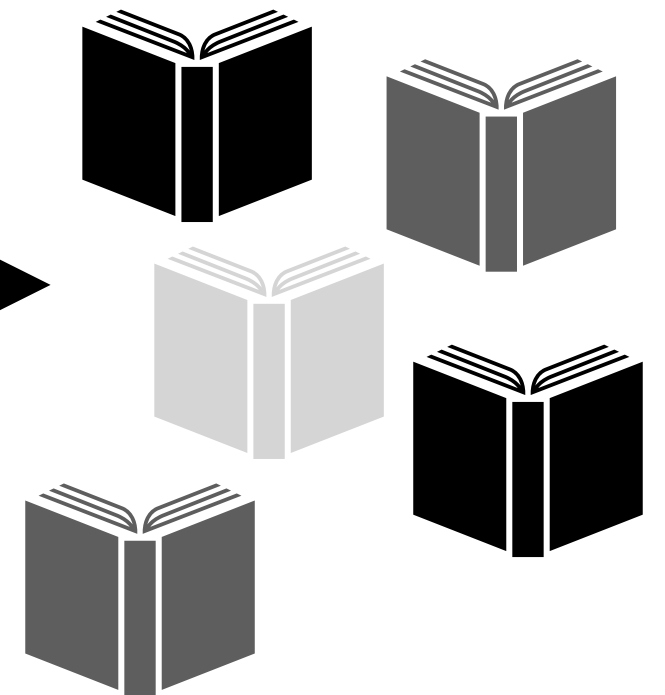
Historical data



model



Suggestions



- **direct preferences:** “liking”, rating, “swiping right”
- **indirect behaviour:** watching, listening, shopping, viewing

- **predicting future behaviour**
- which book will I rate highly
- which song will I put on repeat?

Recommendation Systems = Machine Learning

Two main techniques:

1. Collaborative Filtering



Unsupervised Learning

2. Content-based Filtering



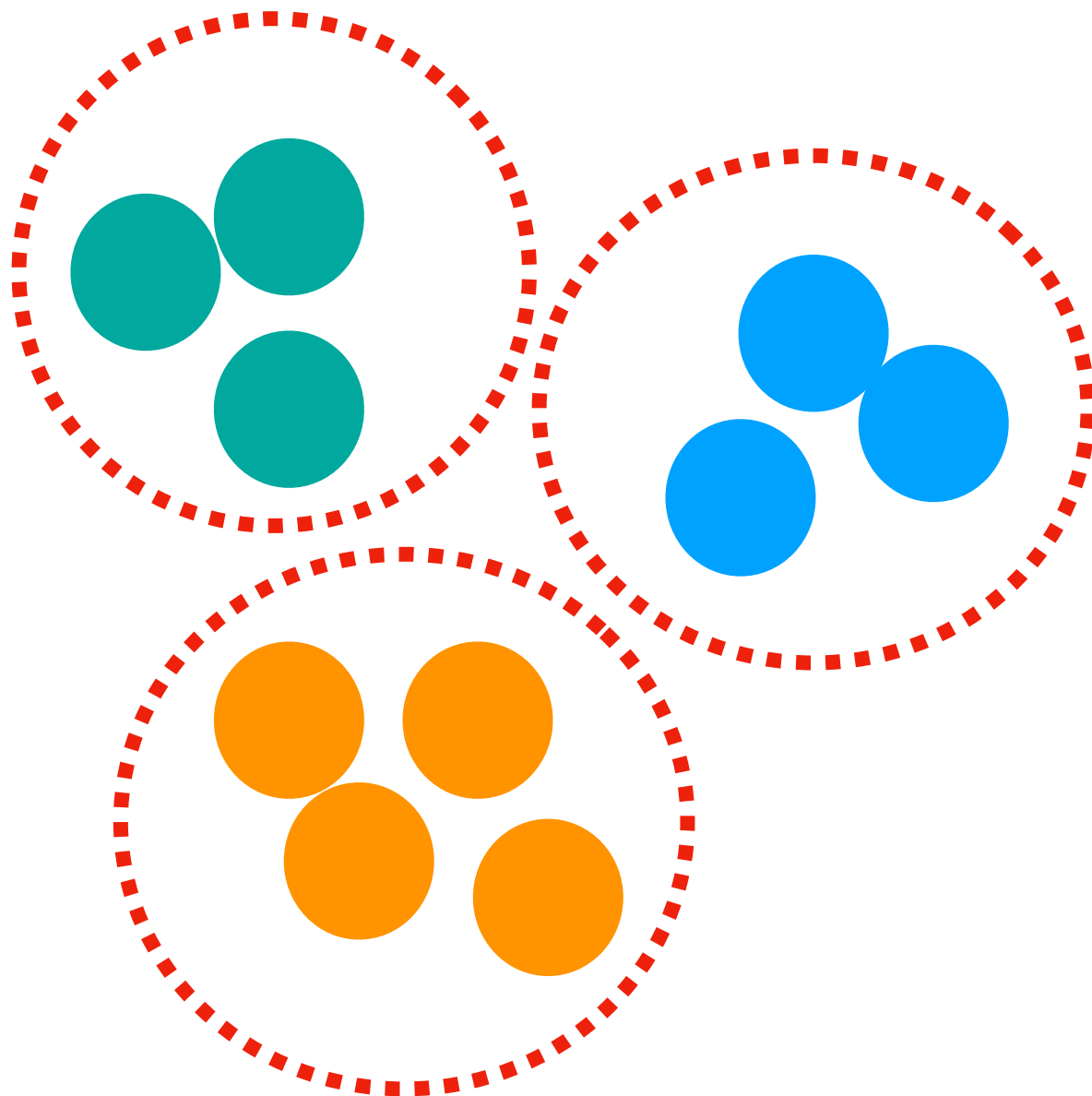
Supervised Learning

Supervised Learning

id	age	gender	profession	ticket price	cabin	survived?
1	24	M	S	10	middle	N
2	60	F	D	80	upper	Y
3	33	M	R	5	lower	N
4	7	F	NA	1	upper	Y
...	
X	27	F	S	25	middle	?

Unsupervised Learning

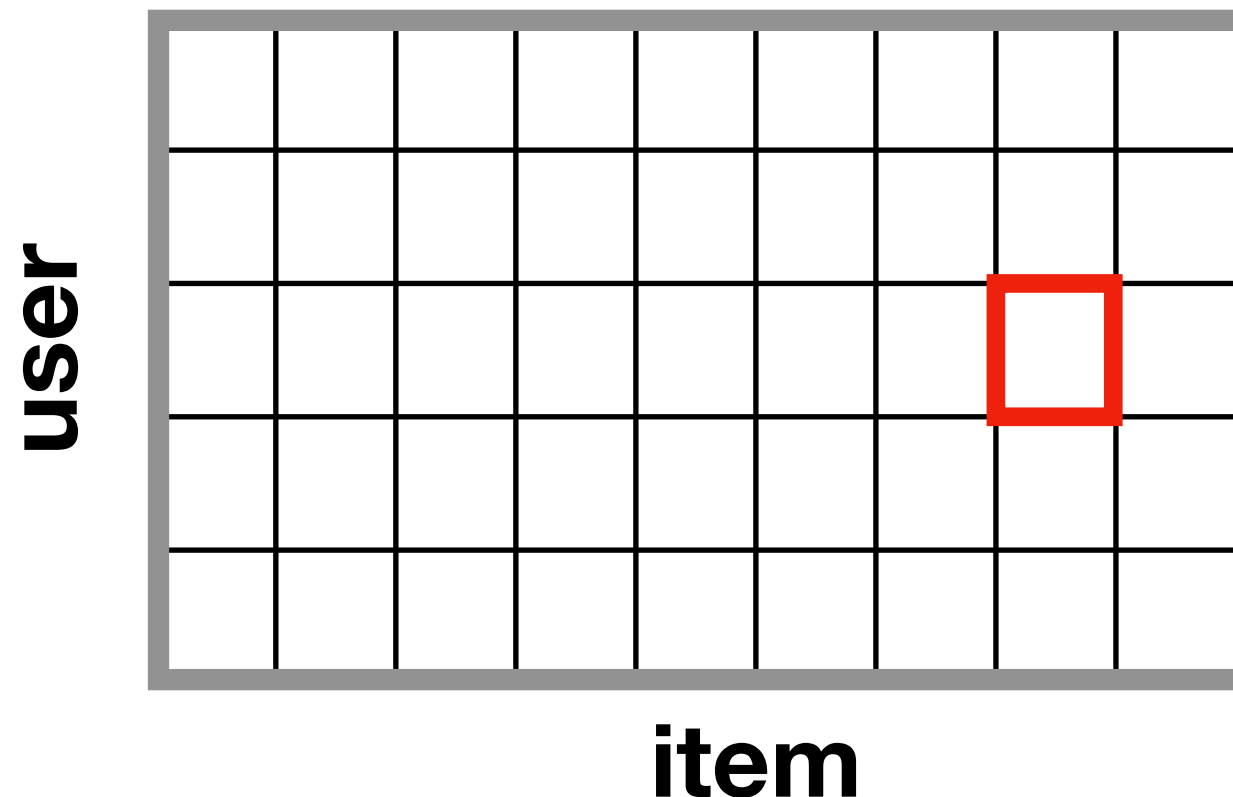
clustering things together



t-SNE plot

Collaborative Filtering

- A type of unsupervised learning
- Assumption: “similar users like similar items”
- Uses a utility (user-item) matrix





	movie 1	movie 2	movie 3	movie 4	movie 5
user 1	1	5	1		
user 2	1	5		4	2
user 3	5	4		2	
user 4	2		5		
user 5	1.5	4.5	1	5	3
user 6		2		4.5	5
user 7	2		4		5



	movie 1	movie 2	movie 3	movie 4	movie 5
user 1	1	5	1		
user 2	1	5	?	4	2
user 3	5	4		2	
user 4	2		5		
user 5	1.5	4.5	1	5	3
user 6		2		4.5	5
user 7	2		4		5



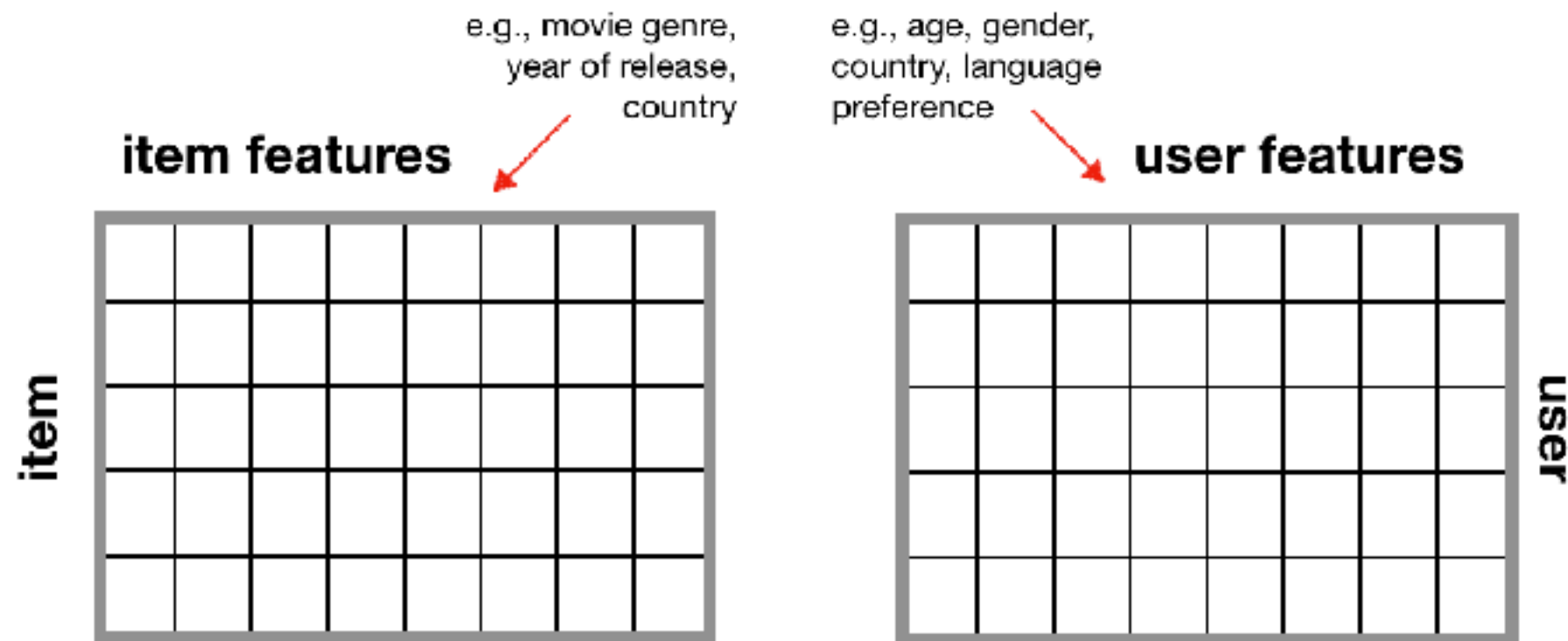
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user 4	2		5		
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user 6		2		4.5	5
user 7	2		4		5

Collaborative Filtering

- Cosine similarity
 - Computes similarity of users and items and generates recommendations using k-Nearest Neighbours (kNN)
 - “Users who liked this item also liked”
- Matrix factorization

Content-Based Filtering

- A type of supervised learning
- Looks at item and user features to make predictions



Content-Based Filtering

movie	year	country	genre	rating
Titanic	1997	USA	drama	3.5
Shawshank	1994	USA	drama	4
Lamerica	1994	Italy	drama	5
Boss Baby	2017	USA	comedy	2
...	
X	2010	Canada	comedy	?

Content-Based Filtering

- **MovieLens Database**

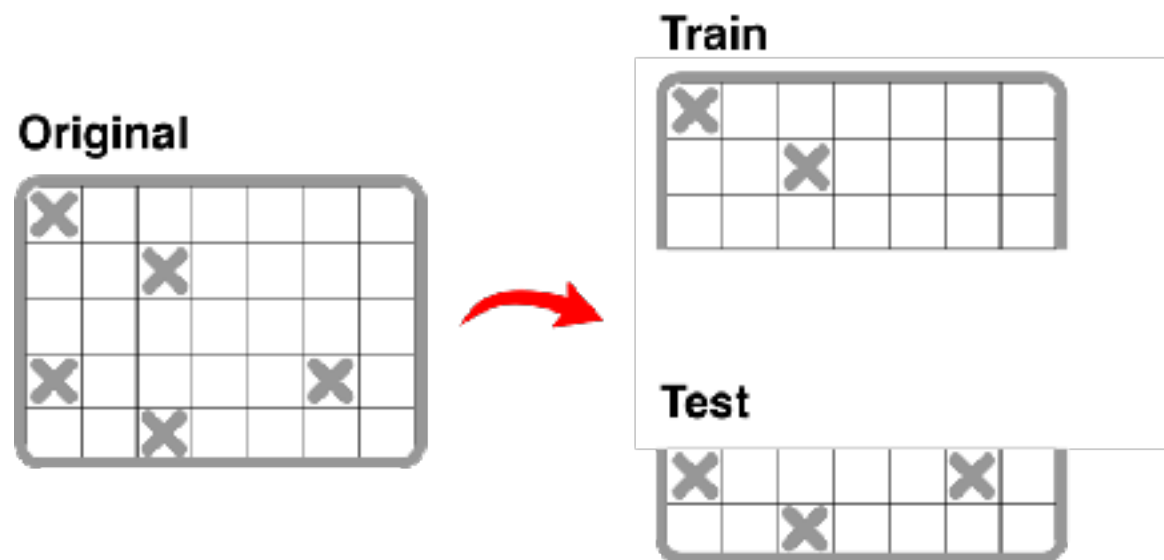
- created in 1997 by a research group at the University of Minnesota
- recommendation system for movies
- open-source data, very active in the machine learning community
- 26,000,000 ratings and 750,000 tag applications applied to 45,000 movies by 270,000 users

How do we evaluate recommendations?

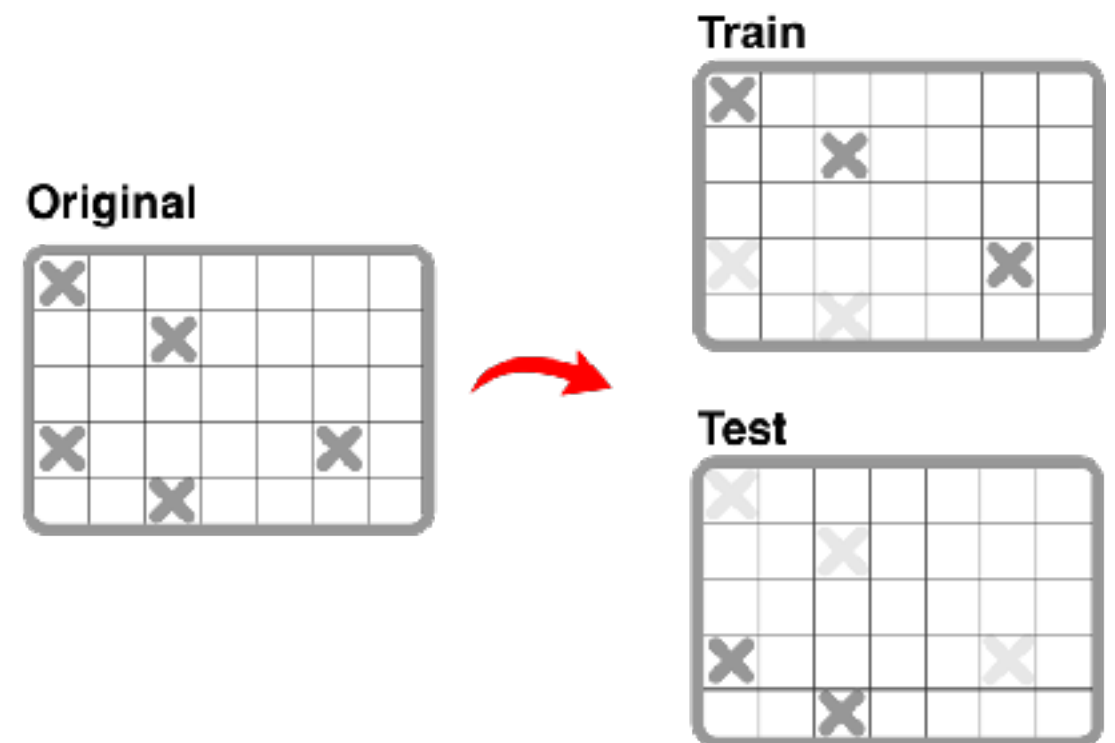
- Gold standard: A/B testing
- Accuracy (content-based filtering)
- Precision and Recall

How do we evaluate recommendations?

Traditional ML



Recommendation Systems



Precision@K and Recall@K

Precision@K

Of the top k recommendations, what proportion are actually “relevant”?

Recall@K

Proportion of items that were found in the top k recommendations.

		Reality	
		liked	did not like
Predicted	liked	True positive	False positive
	did not like	False negative	True negative

$$\text{precision} = \frac{TP}{TP + FP}$$

$$\text{recall} = \frac{TP}{TP + FN}$$

Precision@K and Recall@K

Precision@K

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Implicit vs. Explicit Feedback

- Explicit feedback
 - user directly rates their preference towards an item
- Implicit feedback
 - user behaviour towards an item
 - e.g., listening to song multiple times = positive feedback

The Netflix Challenge

- Open competition in 2009
- Challenge: improve current recommendation system by 10%
- Dataset included **100,480,507 ratings** that ~500K users gave to ~18K movies
 - ➡ (user_id, movie_id, rating_ts, rating)
- BellKor's Pragmatic Chaos improved score by 10.05%