Collaborative Filtering

EECS 349 Machine Learning

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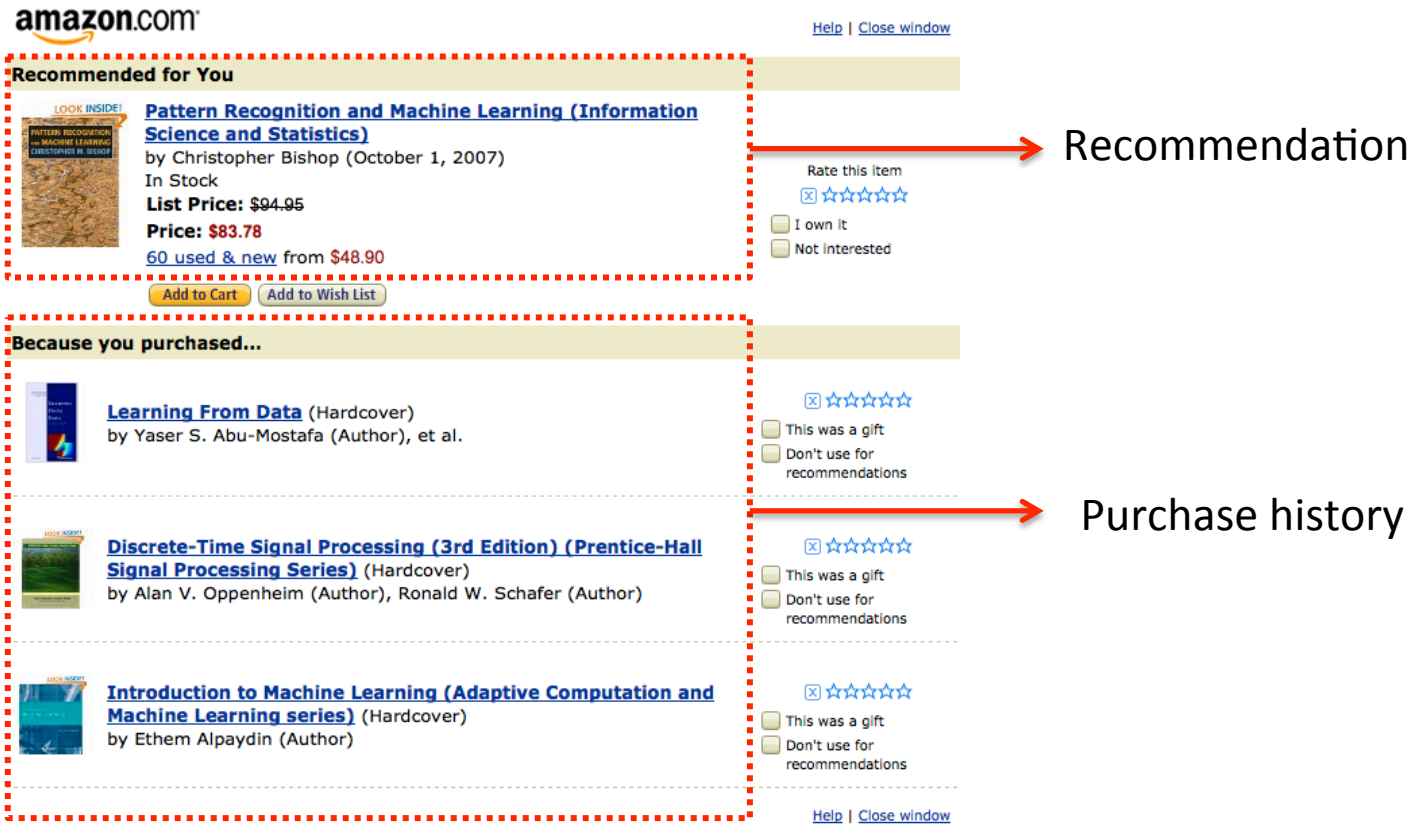
What is Collaborative Filtering?

- Recommendation system
  - Amazon recommends items based on your purchase history and ratings

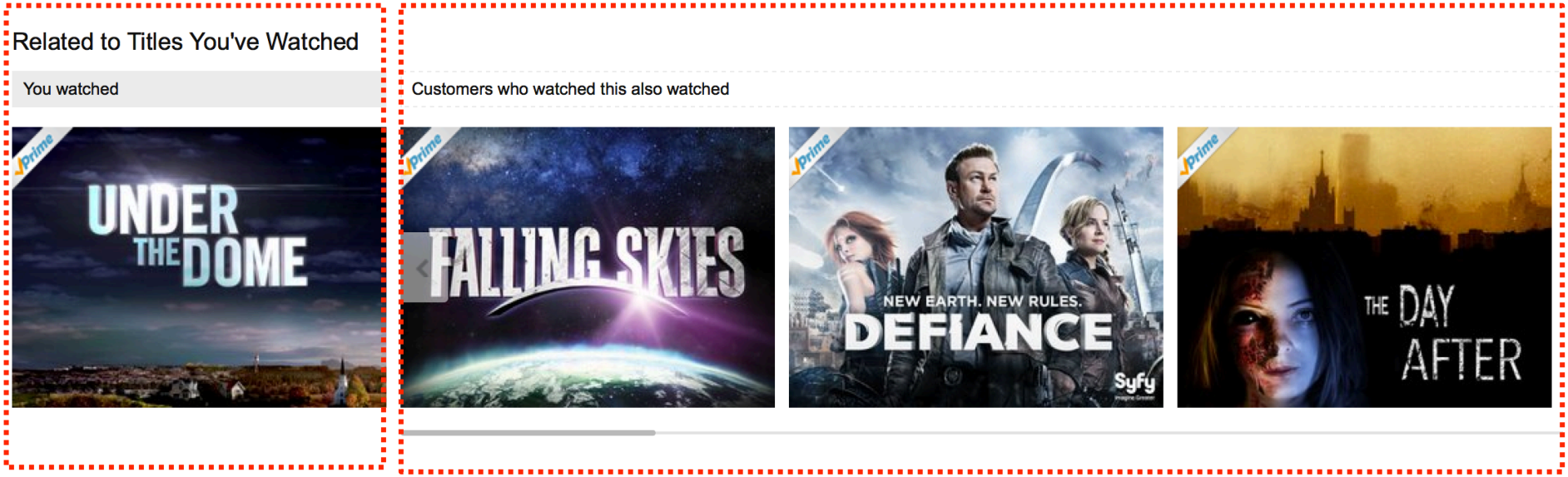


What is Collaborative Filtering?

- Recommendation system
  - Amazon recommends items based on your purchase history and ratings

View history

Recommendation



What is Collaborative Filtering?

- Task: How do I predict what you'll like?

- Two approaches
  - User-based: You will like *item A* because **users** who are similar to you like *item A*.
  - Item-based: You will like *item A* because you like **items** that are similar to *item A*.

User-Based Collaborative Filtering

- Find users that is similar to you and you might like the item the user likes

A

I like..
- Star wars
- Star Trek
- Mission Impossible

B

I like..
- Star wars
- Star Trek
- Mission Impossible
- X-men

***B** is a user who has similar preference to **A**.*
*So **A** would like "X-men" too !!*

Item-Based Collaborative Filtering

- You might like items that are similar to items you already like

A

I like Star wars !

*"Star Trek" is a movie similar to Star Wars because it has "star" in the name. Then, **A** would like "Star Trek" too!*

*Do you think **A** would also like "Dancing with the Star"?*

Feature Selection

- Measuring similarity (of users or items) requires measuring their features.
- Which features should I measure?
- Are there features that are (relatively) insensitive to the particulars of the recommendation tasks?
- User ratings to items or their purchase history is one of the explicit features to measure user preference

implicit features
number of clicks
number of followers…

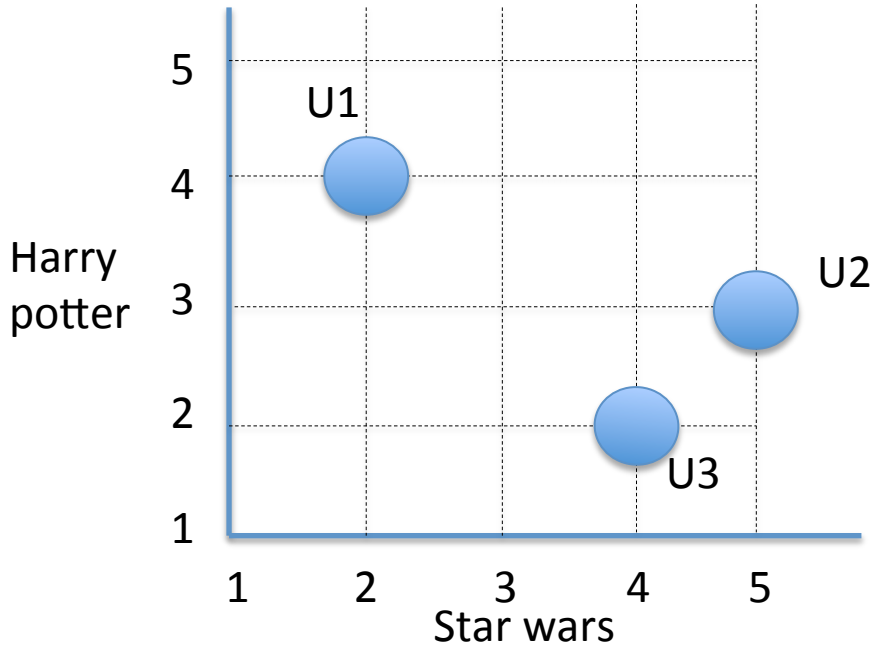
explicit features
user ratings
review
purchase history…

USER-BASED COLLABORATIVE FILTERING

How do we find a user who is similar?

- Distance (or similarity) measure
  - N-dimensional space
- Example: movie ratings of 3 users
  - Ratings from 1 (dislike) to 5 (like)

	U1	U2	U3
Harry Potter	4	3	2
Star Wars	2	5	4



Which similarity measure to use?

- p-norm
  - Manhattan
  - Euclidian
- Pearson Correlation
- Cosine Similarity
- Etc..

Who is the most similar to John?

Example #1

	Inception	Begin again	Once
Brian	5	2	2
Bob	1	4	4
Cathy	2	3	3
John	5	1	2

- Manhattan Distance:

(John, Brian) = 0 + 1 + 0 =1
(John, Bob) = 4 + 3+ 2 =9
(John, Cathy) = 3 + 2 + 1 = 6

Q: Does Manhattan Distance measure similarities properly in this data set?

yes

Who is the most similar to Adam?

Example #2

	Inception	Begin again	Once	Star wars
Bill	2	3	3	2
Brian	5	1	1	5
Adam	3	2	2	3

- Manhattan Distance:

(Adam, Bill) = 1 + 1 +1 + 1 =4

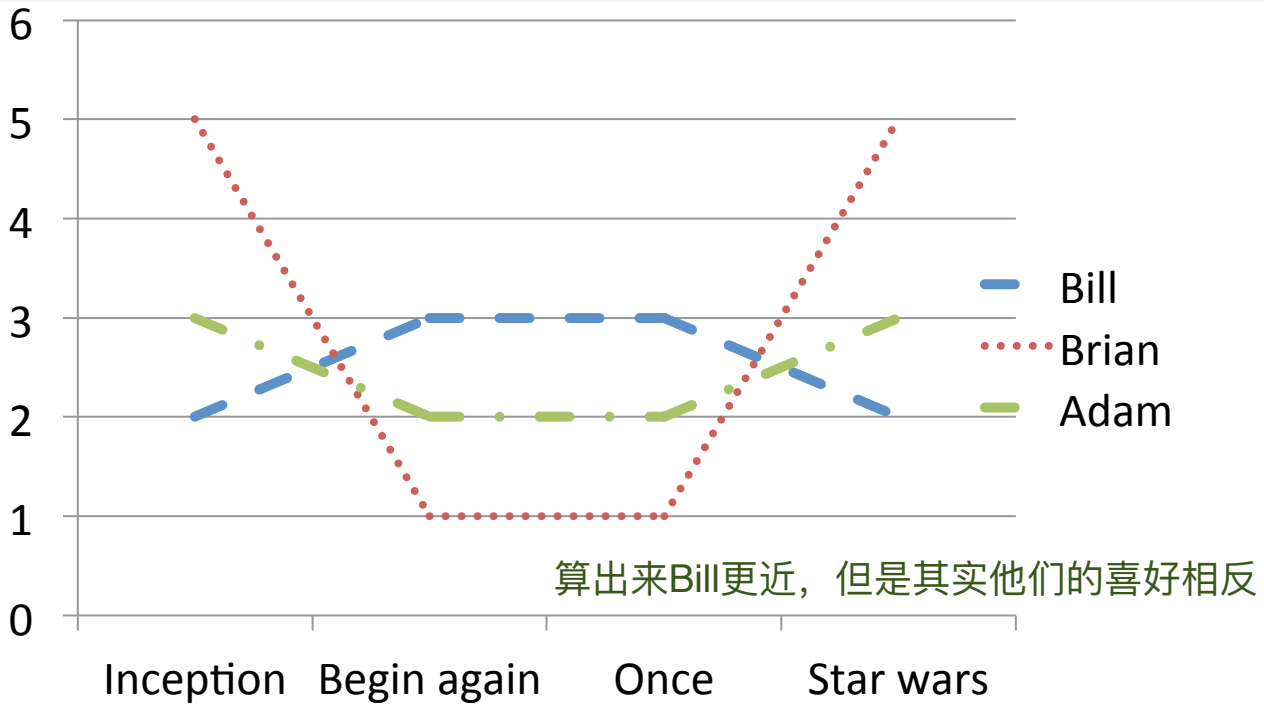
(Adam, Brian) = 2 + 1+ 1 + 2 = 6

Q: Does Manhattan Distance measure similarities properly in this data set?

no

Different users may use different rating scales

Who is the most similar to Adam?



- Manhattan Distance:

(Adam, Bill) = 1 + 1 +1 + 1 =4

(Adam, Brian) = 2 + 1+ 1 + 2 = 6

Q: Does Manhattan Distance measure similarities properly in this data set?

Different users may use different rating scales

Pearson Correlation

- Measure of correlation between two variables
- Pearson correlation coefficient
  - Range (-1, 1)
  - A perfect positive correlation: 1
  - A perfect negative correlation: -1

$$sim(\mathbf{u},\mathbf{v}) = \frac{\sum_{i \in C}(r_{\mathbf{u},i} - \bar{r}_{\mathbf{u}})(r_{\mathbf{v},i} - \bar{r}_{\mathbf{v}})}{\sqrt{\sum_{i \in C}(r_{\mathbf{u},i} - \bar{r}_{\mathbf{u}})^2}\sqrt{\sum_{i \in C}(r_{\mathbf{v},i} - \bar{r}_{\mathbf{v}})^2}},$$

In Python,

```
>> import scipy.stats
>> scipy.stats.pearsonr(array1, array2)
```

Cosine Similarity

- Measure of similarity between two vectors
  - Range from -1 (opposite) to 1 (same)

- Cosine similarity between vector *a* and *b:*

$$sim(a,b) = \frac{a \cdot b}{|a| * |b|}$$

Who is the most similar to Adam?

Example #2

	Inception	Begin again	Once	Star wars
Bill	2	3	3	2
Brian	5	1	1	5
Adam	3	2	2	3

- Pearson Correlation:

(Adam, Bill) = -1
(Adam, Brian) = 1

Q: Does Pearson Correlation measure similarities properly in this data set?

How to predict ratings to unrated items

- User-based K- Nearest Neighbor Collaborative Filtering

  recommendation: items you might like, is presents top k items

  prediction: how much you will like items,using some rating scale

  1) Define a similarity measure

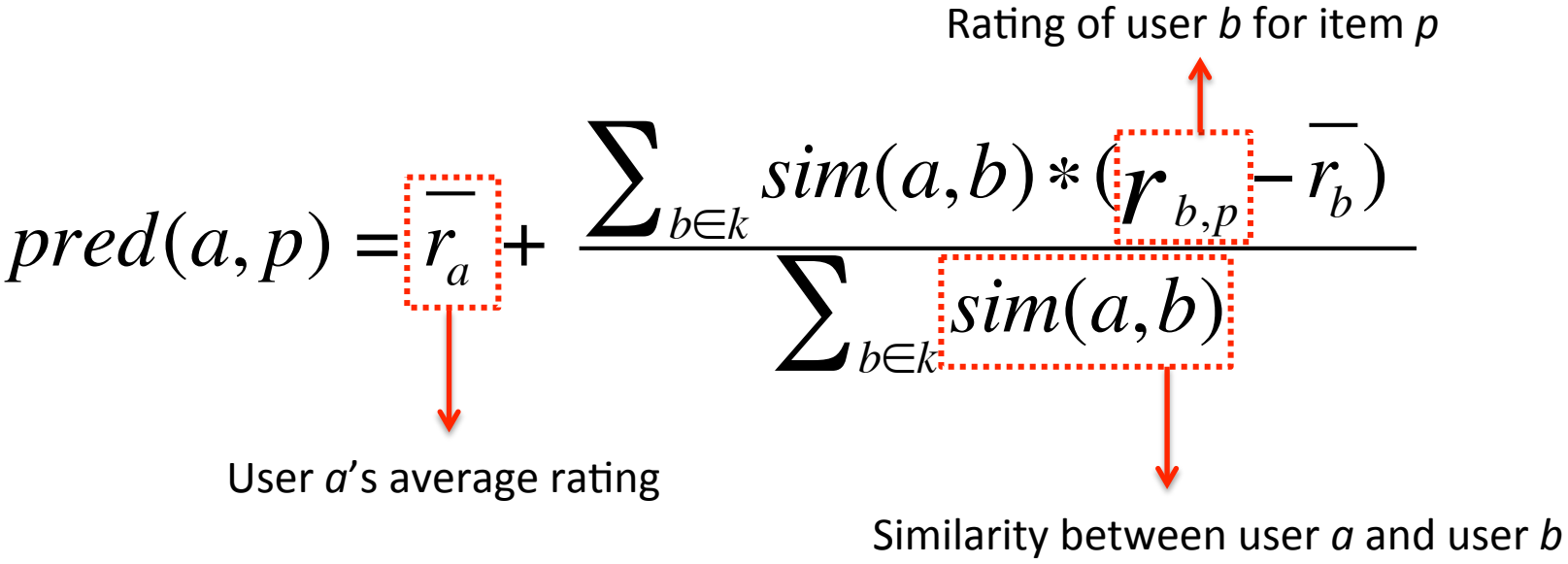
  2) Pick k users that had similar preferences to those of current user

  3) Compute a prediction from a weighted average of k nearest neighbors' ratings *(see the next slide)*

  You need to do experiments to find optimal k value.

How to predict ratings to unrated items

- Prediction for the rating of user a for item p.



Let's practice user-based k-NN CF

- In this practice and our homework, we will use much simpler way to compute a prediction of rating
  1) Define a similarity measure
  2) Pick k users that had similar preferences to those of current user
  3) **Pick the mode of the top k nearest neighbors as the predicted rating**

不用计算

- ex) If you pick 3 neighbors and their ratings to the target item are (2, 2, 3), then the prediction will be 2.

Practice: User-based k-NN CF (k=1)

Example #1: How would John rate Star wars?

	Inception	Begin again	Once	Star wars
Brian	5	2	2	4
Bob	1	4	4	2
Cathy	2	3	3	1
John	5	1	2	?

Manhattan Distance:

(John, Brian) = 0 + 1 + 0 =1

(John, Bob) = 4 + 3+ 2 =9

(John, Cathy) = 3 + 2 + 1 = 6

The nearest neighbor: Brian

John's rating to Star wars: 4

Practice: User-based k-NN CF (k=1)

Example #2: How would John rate Avatar?

	Inception	Begin again	Once	Star wars	Avatar
Brian	2	3	3	1	4
Bob	5	1	1	5	2
Cathy	5	1	2	4	1
John	3	2	2	3	?

Manhattan Distance:
(John, Brian) = 1 + 1 +1 + 2 =5
(John, Bob) = 2 + 1+ 1 + 2 = 6
(John, Cathy) = 1 + 1 + 1 + 1= 4

The nearest neighbor: Cathy
John's rating to Avatar: 1

Pearson Correlation Coefficient
(John, Brian) = -0.90
(John, Bob) = 1.0
(John, Cathy) = 0.95

The nearest neighbor: Bob
John's rating to Avatar: 2

ITEM-BASED COLLABORATIVE FILTERING

How to predict ratings to unrated items

- **Item-based** K- Nearest Neighbor Collaborative Filtering

  1) Define a similarity measure between **items**

  2) Pick k items rated by the current user similar to the target item

  3) Compute a prediction from a weighted average of the k similar items' ratings

Let's practice **item-based** k-NN CF

- In this practice and our homework, we will use much simpler way to compute a prediction of rating
  1) Define a similarity measure between **items**
  2) Pick k items rated by the current user similar to the target item
  3) **Pick the mode of the top k nearest neighbors as the predicted rating**

  - ex) If you picked 3 items and current user's ratings to the 3 items are (2, 2, 3), then the prediction will be 2.

Practice: Item-based k-NN CF (k=1)

Example #1

	Inception	Begin again	Once	Star wars
Brian	5	2	2	4
Bob	1	4	4	2
Cathy	2	3	3	1
John	5	1	2	?

Manhattan Distance:

(Star wars, Inception) = 1 + 1 + 1 =3
(Star wars, Begin again) = 1 + 2+ 2 =5
(Star wars, Once) = 2+2+2 = 6

The most similar item to Star wars: Inception
John's rating to Star wars: 5

The Cold Start Problem

- What if this user has never rated anything before?
- What if nobody has rated this item before?
- Additional information. For example,
  - Ask users to rate some initial items
  - Demographic information (人口学的) for users
  - Content analysis or metadata (元数据) for items

Missing values

- Missing values in user-rating matrix
  - What if two users have rated different sets of things? How do we compare them?
  - What if two items have been rated by disjoint sets of users? How do we compare them?

Dealing with missing values

Example

	Inception	Begin again	Once	Star wars	Avatar
Brian	2	?	3	?	4
Bob	5	1	1	5	2
Cathy	5	?	2	2	1
John	5	?	2	3	?

Dealing with missing values

Example

	Inception	Begin again	Once	Star wars	Avatar
Brian	2	0	3	0	4
Bob	5	1	1	5	2
Cathy	5	0	2	2	1
John	5	0	2	3	?

Dealing with missing values

- Discarding the person/item from comparison?
  - It does not solve cold start problem
  - What if the data set is so sparse? 稀少
- Putting in a crazy number (-1000) for missing values?
- Putting in a random number?
- Putting in a mean (median) value?
  - Mean value of what set?
- Other advanced imputation technique?

Make a decision

- Which similarity (or distance) measure to use?
- How many neighbors to pick?
- How to weight neighbors chosen?
- User-based or item-based?
- How to deal with missing values?