

Week 2: Basic Concepts and Similarity Measures

CS3448: Recommender Systems /
CSX4207/ITX4207: Decision Support
and Recommender Systems

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Objectives

- To determine weak points of non-personalized recommendations
- To understand types of data used in generating recommendations in personalized RSs
- To understand basic concepts used in generating recommendations in personalized RSs
- To understand scoring and ranking of data
- To understand basic similarity measures

Outlines

- **Weak Points of Non-Personalized RS**
- Preferences and Ratings
- Predictions and Recommendations
- Scoring and Ranking
- Basic Similarity Measures

Revisiting Non-Personalized RS

bm/r/ruths-chris-steak-house-austin

PLACES LISTS BUZZ ZAGAT AUSTIN MORE

RUTH'S CHRIS STEAK HOUSE

Steakhouse • Downtown • \$\$\$

THE ZAGAT REVIEW

4.7 FOOD 4.5 DECOR 4.5 SERVICE

This Downtown outpost of the national chain is **"always on the mark"** thanks to **"excellent"** steaks you can cut **"with a fork"** and **"wonderful"** service in **"calm, classy"** surroundings; the bar can be a power scene, especially at happy hour, and tabs a bit **"pricey"**, but most agree it's **"worth the cost."**

Zagat reviews are compiled from individual user reviews. [Write your review.](#)

[VIEW MENU](#)

MAKE A RESERVATION AT RUTH'S CHRIS STEAK HOUSE

08/05/2016 7:00 PM 2 people [FIND A TABLE](#)

ADDRESS
107 West 6th Street | Map
Austin, Texas 78701
512-477-7884
www.ruthschris.com/restaurant-locations/austin/?utm_

TODAY'S HOURS
4:30PM - 11:00PM

RUTH'S CHRIS STEAK HOUSE APPEARS IN THESE LISTS

Austin Restaurants with Best Decor

Austin's Best

- Generating Recommendations
 - Rating = {1, 2, 3, 4, 5}
 - Score = MEAN(ratings)

UCHI
Japanese | Bouldin Creek

Food Decor Service Cost

1 2 3 4 5 1 2 3 4 5 1 2 3 4 5 \$ (Optional)

Per person with drink and tip

Your review Your email

Describe your experience at Uchi Email Address

☐ I'm not a robot

400 characters remaining

[Submit](#) [Terms & conditions](#)

Weak Points of Non-Personalized RS

- Side-effects of averaging
 - Moderate restaurants with good scores (many opinions are exaggerated.)
 - Great restaurants with moderate score (many typical people may not like niche recipe.)
 - Not aware of concept drift (Some restaurant was very good in the past, but it is worse now.)
- Recommendations not customized to individual needs
 - E.g.,
 - Suggest top 10 greatest hits albums all in Pop to A Cappella's fan
 - Suggest products in supermarkets based on best selling ones to every customer

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Personalized RSs

- Make use of **individuals' information** to generate recommendations
 - Preferences
 - Ratings

Types of Preferences

Explicit

- Rating
- Vote
- Review

Implicit

- Click to view
- Buy
- Follow

How to **classify** **user preferences**?

How do you **classify**

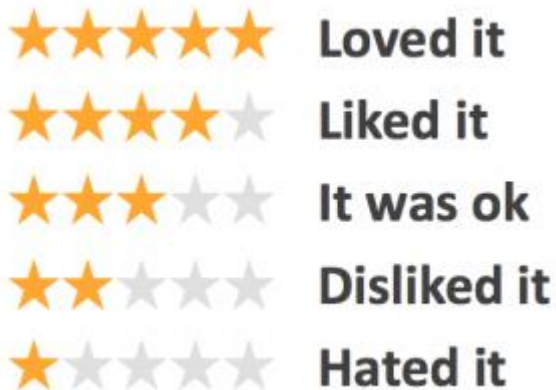
- 'post', 'like', 'comment' and 'share' in Facebook?
- 'tweet' and 'retweet' in Twitter?

Explicit Ratings

- Ask users straightforwardly for scoring a given item.
- Examples of ratings
 - **Star ratings**
 - Typical 5 stars (with or without half star)
 - **Likert scale**
 - A typical five-level Likert item: 'Strongly disagree', 'Disagree', 'Neither agree nor disagree', 'Agree', 'Strongly agree'
 - Different level Likert scales¹: 3, 7, 10, etc.

¹More info: <http://www.socialresearchmethods.net/kb/scallik.php>

Examples of Star Rating



★★★★★ **5 Stars: Extraordinary**

★★★★☆ **4 Stars: Excellent**

★★★☆☆ **3 Stars: Very Good**

★★☆☆☆ **2 Stars: Good**

★☆☆☆☆ **1 Star: Fair**

☆☆☆☆☆ **0 Stars: Poor**

Examples of Likert Scales

Likert Scales

Please fill in the number that represents how you feel about the computer software you have been using

I am satisfied with it

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

It is simple to use

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

It is fun to use

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

It does everything I would expect it to do

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

I don't notice any inconsistencies as I use it

(1)	(2)	(3)	(4)	(5)
Strongly Agree	Agree	Neither	Disagree	Strongly Disagree

Likert Scales

Please circle the number that represents how you feel about the computer software you have been using

I am satisfied with it

Strongly Disagree ---1---2---3---4---5---6---7--- Strongly Agree

It is simple to use

Strongly Disagree ---1---2---3---4---5---6---7--- Strongly Agree

It is fun to use

Strongly Disagree ---1---2---3---4---5---6---7--- Strongly Agree

It does everything I would expect it to do

Strongly Disagree ---1---2---3---4---5---6---7--- Strongly Agree

I don't notice any inconsistencies as I use it

Strongly Disagree ---1---2---3---4---5---6---7--- Strongly Agree

It is very user friendly

Strongly Disagree ---1---2---3---4---5---6---7--- Strongly Agree

Vote

- Likes
- Thumbs

Part of the Collection: *Star Trek* [View Collection >](#)

TOMATOMETER **83%**
Average Rating: 6.9/10
Reviews Counted: 216
Fresh: 180
Rotten: 36

AUDIENCE SCORE **83%**
Average Rating: 4.0/5
User Ratings: 55,064

ADD YOUR RATING

[+ WANT TO SEE](#) [- NOT INTERESTED](#)

TICKETS & SHOWTIMES

The movie doesn't seem to be playing near you.

Bruno Mars - Count on me [Official Video]


Domenico Capasso [Subscribe](#) 3,468

6,081,321 views

[+ Add to](#) [Share](#) [More](#)

[23,594](#) [1,810](#)

Review

 Under Armour Storm Hustle II Backpack
\$42.00 - \$57.81

Top Customer Reviews

★★★★★ Love the customer service!

By [Ingesbooks](#) on September 11, 2015

Size: One Size | Color: Black | **Verified Purchase**

I bought this for my college books and computer. The third week of school the top ripped. I contacted under armour and they sent me a brand new one and I returned the ripped one. They stand behind everything!! ☺☺☺☺☺



1 Comment | 125 people found this helpful. Was this review helpful to you? [Report abuse](#)

Excellent

4.2 / 5

“We are pleasantly surprised with the warm hospitality of the staffs at Movenpick Hotel;...”
Jul 28, 2016

“Overall nice place with clean environment and great staffs. The staffs are friendly...”
Jul 18, 2016

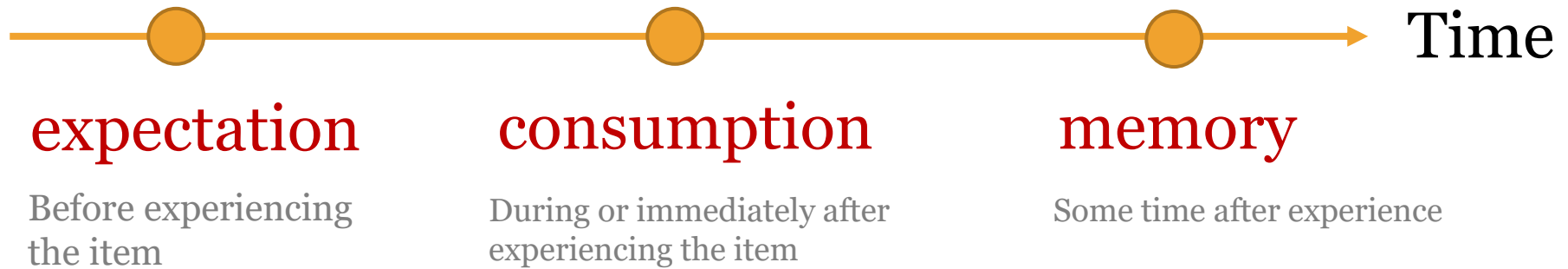
[See all 125 Hotels.com reviews](#)



From 716 reviews

TripAdvisor Traveller Rating

Timing to Give Ratings



Issues of Rating Usages

- Reliability and accuracy
- User preferences drifting
- Rating's meaning



UNDERSTANDING ONLINE STAR RATINGS:

★★★★★ [HAS ONLY ONE REVIEW]

★★★★☆ EXCELLENT

★★★★☆ OK

★★★★☆

★★★★☆

★★★☆☆

★★☆☆☆

★★☆☆☆

★☆☆☆☆

CRAP

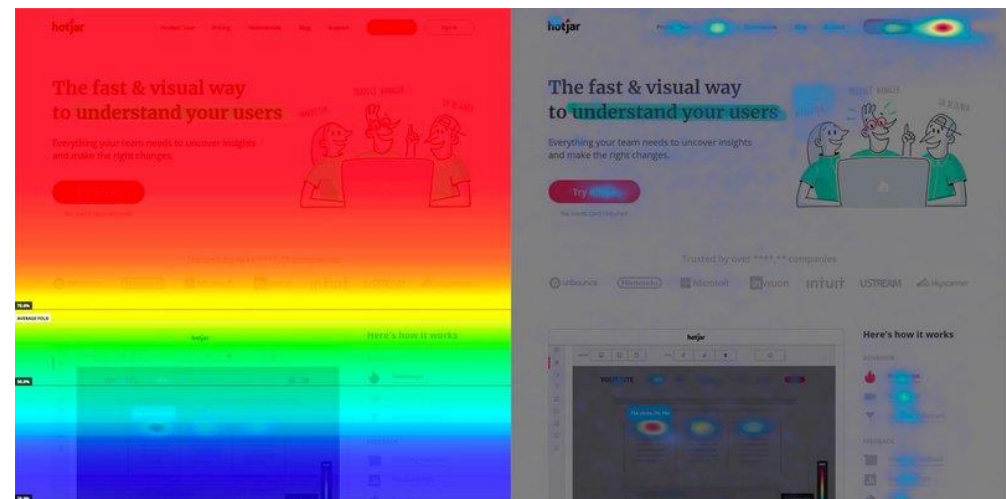
Implicit Preferences

- Observe from user behaviors
- Not easily interpreted as ratings
- Give more details beside ratings

□ E.g.,

- Reading/watching time
- Click on link/ad
- Add to cart/buy
- Search/share content

Heatmaps



Source: <https://www.hotjar.com/behavior-analytics-software/>

How tracking user behavior on your website can improve customer experience: <https://www.hotjar.com/blog/user-behavior/>

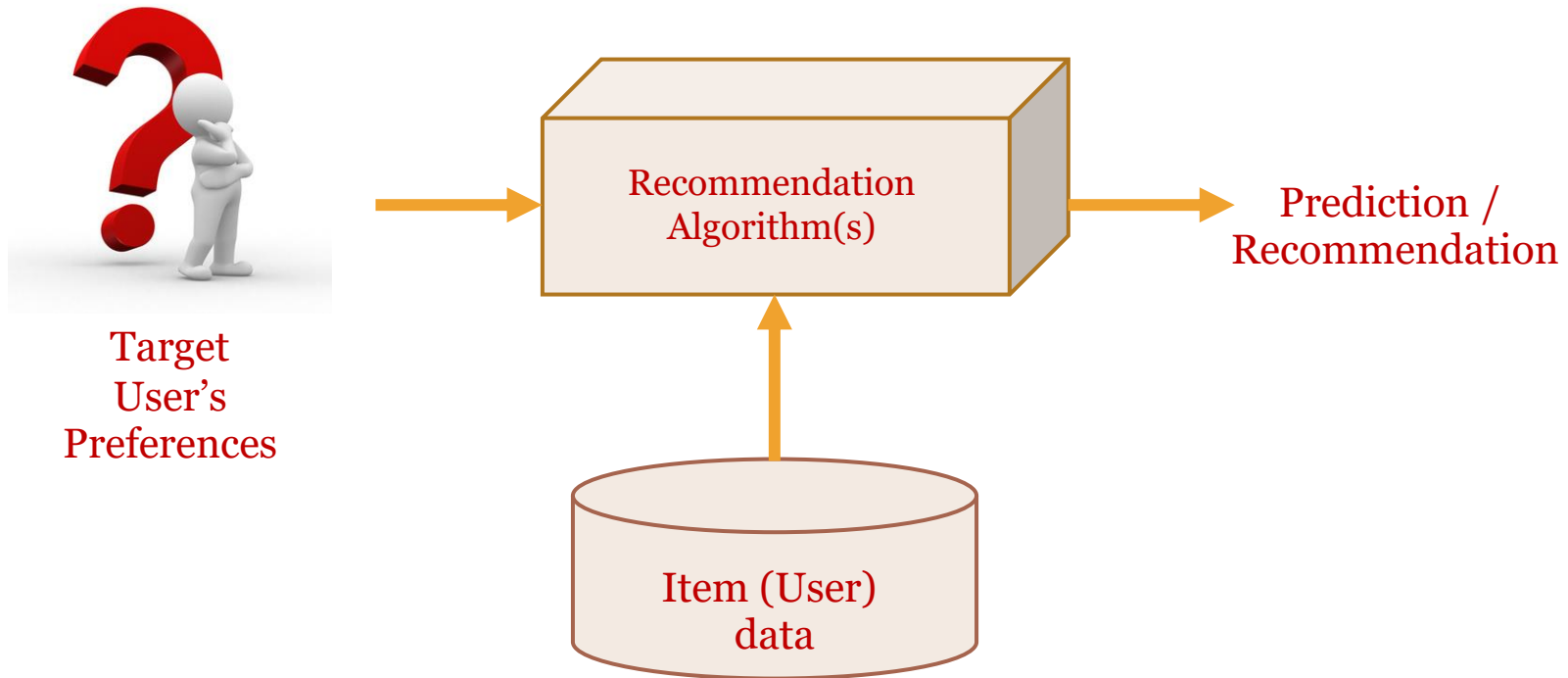
Advantages and Disadvantages

	Explicit Ratings	Implicit Preference
Used to generate personalized recommendations	Yes	Yes
Easy to interpretation	Yes	No
Effort to collect data	require user efforts	great amount of data available
Reliability and accuracy	more	less
User preferences drifting	may be concerned	-
Scale/represent actions	easy	more challenge

Outlines

- Weak Points of Non-Personalized RS
- Preferences and Ratings
- **Predictions and Recommendations**
- Scoring and Ranking
- Basic Similarity Measures

How to Generate Prediction/Recommendation?



Prediction vs Recommendation

Prediction

- Estimate how much target users will like an item (a numerical value).

Recommendation

- Rank items based on how much target users will like an item. (e.g., top 10 greatest hits albums)
- Simplify as 'shown' items

Prediction vs Recommendation

The screenshot shows the Reddit homepage with several annotations. A red circle highlights the 'Popular posts' section, which is labeled 'Predictions' in a yellow box. This section contains two posts: one from r/AskReddit titled 'What 90s song will always be a banger?' and another from r/politics titled 'Megathread: The US House of Representatives approves measure to restrain President Donald Trump's actions on Iran'. A blue circle highlights the 'Growing Communities' section, which is labeled 'Recommendations' in a yellow box. This section lists five communities: r/worldnews, r/Home, r/politics, r/australia, and r/news. The 'Predictions' label is positioned to the left of the 'Popular posts' section, and the 'Recommendations' label is positioned to the right of the 'Growing Communities' section.

reddit Popular Search Reddit LOG IN SIGN UP

Popular posts

44.2k ↑ r/AskReddit · Posted by u/Dimeliora 11 hours ago 23.1k Comments Share Save + JOIN

What 90s song will always be a banger?

29.1k ↑ r/politics · Posted by u/PoliticsModeratorBot 4 hours ago 4.2k Comments Share Save + JOIN

Megathread: The US House of Representatives approves measure to restrain President Donald Trump's actions on Iran Megathread

PROMOTED · Posted by u/redditads 2 months ago Reach your audience on Reddit

1 r/worldnews

2 r/Home

3 r/politics

4 r/australia

5 r/news

VIEW ALL

Predictions

Recommendations

Prediction vs Recommendation

← → ↻ hotels.com/search.do?resolved-location=CITY%3A1366745%3AUNKNOWN%3AUNKNOWN&destination-id=1366745&q-destination=Taipei,%20Taiwan... 🔍 ☆ 📄 👤 ⋮

Apps Gmail YouTube Maps Translate Saved UI/UX DataMining RS Other bookmarks

Deals List your property Hotels.com™ Rewards

Destination, property or landmark: Taipei, Taiwan

Check-in: 12-01-2020 Sunday

Check-out: 13-01-2020 Monday

Rooms: 1

Adults: 2 Aged 18+

Children: 0 0-17

Search

Taipei, Taiwan

Sort by: Featured Ⓢ Star rating Distance Guest rating Price

Narrow results:

e.g. Hilton

Popular filters

- ☐ Free Breakfast
- ☐ Pool
- ☐ Free wifi
- ☐ Free Parking
- ☐ Pet Friendly

Nightly Price

฿0 to ฿25,000+

Star rating

- ☐ 5-star
- ☐ 4-star
- ☐ 3-star
- ☐ 2-star
- ☐ 1-star

Today's Best Deal save 40%

Dandy Hotel Nanmu Branch

No.2, Ln. 728, Sec. 6, Zhongshan N. Rd., Shilin Dist., Taipei, 111, Taiwan

3.5-star

- Shilin
- 8.8 km to City centre
- 7.7 km to Taipei Station

Collect nights

Free parking Airport transfer

Air Conditioning

Loved by guests

Exceptional 9.4

406 Hotels.com guest reviews

~~฿3,461~~ **฿1,897**

We have 1 left at

Choose Room

Just Sleep - NTU

No.83, Sec. 4, Roosevelt Road, Da'an District, Taipei, 10673, Taiwan

3.5-star

- Daan
- 3.0 km to City centre
- 4.2 km to Taipei Station

Collect nights

Loved by guests

Exceptional 9.4

25 Hotels.com guest reviews

฿2,607

We have 2 left at

Choose Room

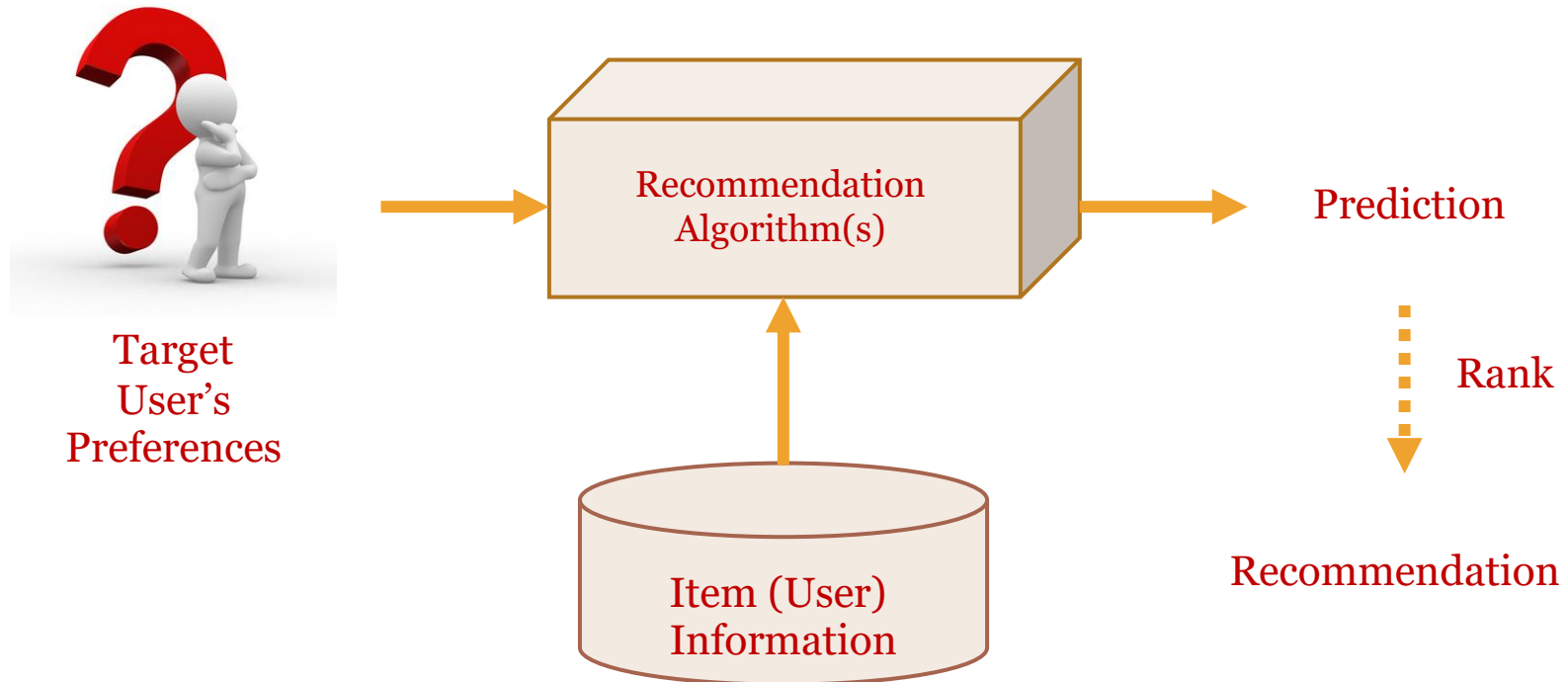
Recommendations

Predictions

Strong and Weak Points

Predictions	Recommendations
+ helps quantify item	+ provides good choices as a default
- provides something empirical	- Less explore if top-n are not attractive

How to Generate Prediction/Recommendation?



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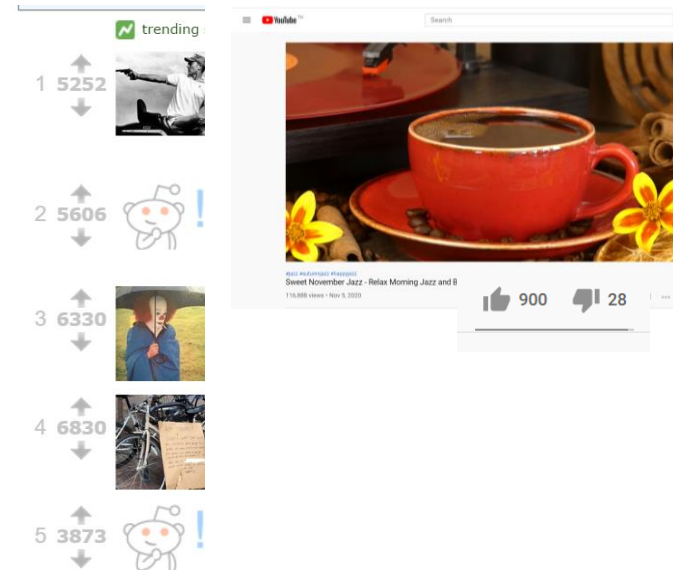
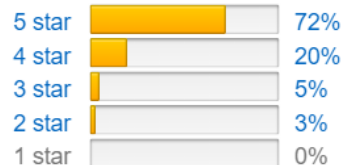
Displaying Aggregating Preferences

- Simple scoring
 - Number of upvotes (likes)
 - Average rating or upvote proportion
 - Percentage of ≥ 4 stars ('positive')
- Full distribution

Customer Reviews

★★★★★ 39

4.6 out of 5 stars



Note:

Aggregating preference (Predict)
Rank items (Recommend)

Ranking Approaches



Rank by predictions



Rank by frequency/quantity



Rank by timing



Rank by domain or business objectives



Etc.

Ranking Considerations

- **Confident levels** (confidence on goodness of an item)
- **High-risk, high-reward** or **conservative** recommendation
- **Domain and business considerations** in terms of
 - Lifetime period
 - Business objectives



Pros and Cons of Mean

Pros

- Present an overall picture of community's opinion
- Widely used
- Calculate easily

Cons

- Few ratings affects low confidence.
- Not reflect opinion of a niche controversial group

Cons and Solutions of Mean

- Cons: **few ratings affects low confidence.**
 - Solutions:
 - Scoring of every item is originally average.
 - Ratings will be adjusted to non-averageness wrt to user preferences.
 - k (a damping term) controls **strength** of evidence required.
 - μ is **global mean**.

$$\text{damped_mean}(i) = \frac{\sum_u r_{ui} + k\mu}{n + k}$$

- Cons: **not reflect opinion of a niche controversial group**
 - Solutions: Personalization

An Example

$$\text{damped_mean}(i) = \frac{\sum_u r_{ui} + k\mu}{n + k}$$

Annotations:
 - **item 'i'** points to i in the denominator.
 - **global mean** points to μ in the numerator.
 - $|u_i|$ points to n in the denominator.

User	Movie	Rating
Ann	Zootopia	2
Pete	Zootopia	2
Kate	Zootopia	3
Ann	Mona	2
Pete	Mona	3
Ann	Big Hero	4
Kate	Big Hero	3

- Suppose that **k** = 5
 - $\mu = 19/7 = 2.714$
 - $\text{damped_mean}(\text{'Zootopia'})$
 $= [(2+2+3) + (5 \times 2.714)] / (3+5)$
 $= 2.57$

Notice: when there are **a few ratings**, it will damp some **extreme positive ratings**.

Note. If using a simple mean, the calculated rating is 2.33.

$$\Delta = 2.57 - 2.33 = +0.2$$

An Example (Cont.)

User	Movie	Rating
u1	Zootopia	4
u2	Zootopia	3
u3	Zootopia	2
u4	Zootopia	3
u5	Zootopia	3
u6	Zootopia	2
u7	Zootopia	4
u8	Zootopia	2
u9	Zootopia	3
u10	Zootopia	3
Ann	Zootopia	2
Pete	Zootopia	2
Kate	Zootopia	3
Ann	Mona	2
Pete	Mona	3
Ann	Big Hero	4
Kate	Big Hero	3

- Suppose that $k = 5$

- $\mu = 48/17 = 2.824$
- $\text{damped_mean}(\text{'Zootopia'})$
 $= (36 + (5 * 2.824)) / (13 + 5)$

$$= 2.784$$

Notice: when the number of rating increases, the damping factor has less effect.

Note. If using a simple mean, the calculated rating is 2.769.

$$\Delta = 2.784 - 2.769 = +0.015$$

Hacker News Ranking Algorithm

$$\text{Score} = (P-1) / (T+2)^G$$

where,

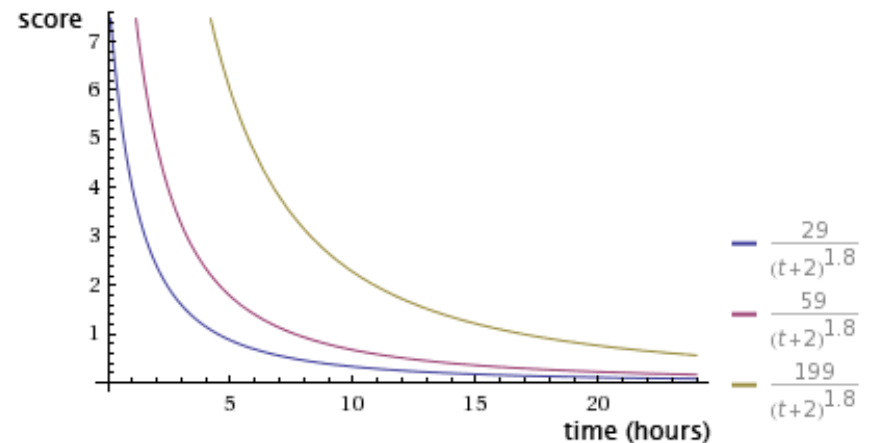


P = points of an item (upvote – downvote)

T = time since submission (in hours)

G = Gravity (defaults is 1.8.)

How score is behaving over time



Q: According to the graph given, when will the score of an item decrease to 1?

The Default Story Algorithm in Reddit (Hot Ranking)

$$f(t_s, y, z) = \underbrace{\log_{10} z}_{\text{Factor of \#upvote}} + \underbrace{(yt_s / 45000)}_{\text{Factor of time (aging)}}$$

t_s = Time (in seconds) since Reddit epoch,

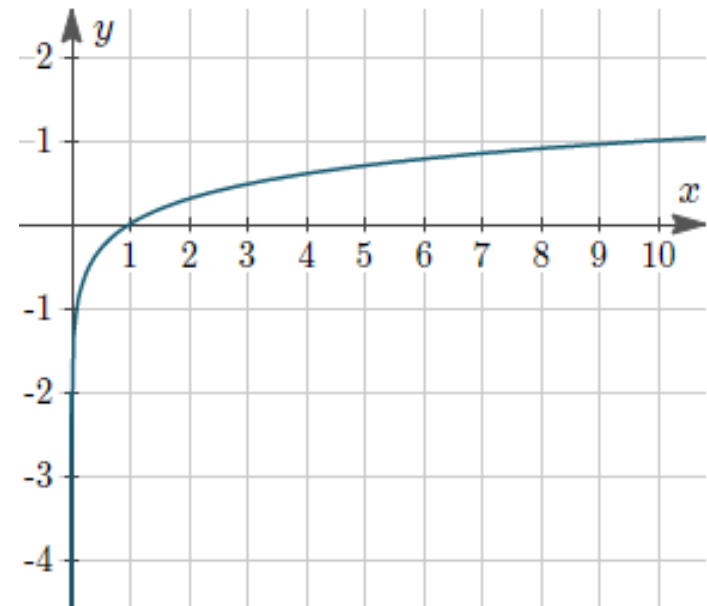
epoch = datetime(1970, 1, 1)

x = #upvotes – #downvotes

$$z = \begin{cases} x & \text{if } x \geq 1 \\ 1 & \text{if } x < 1 \end{cases}$$

$y \in \{-1, 0, 1\}$, y denotes a signed function

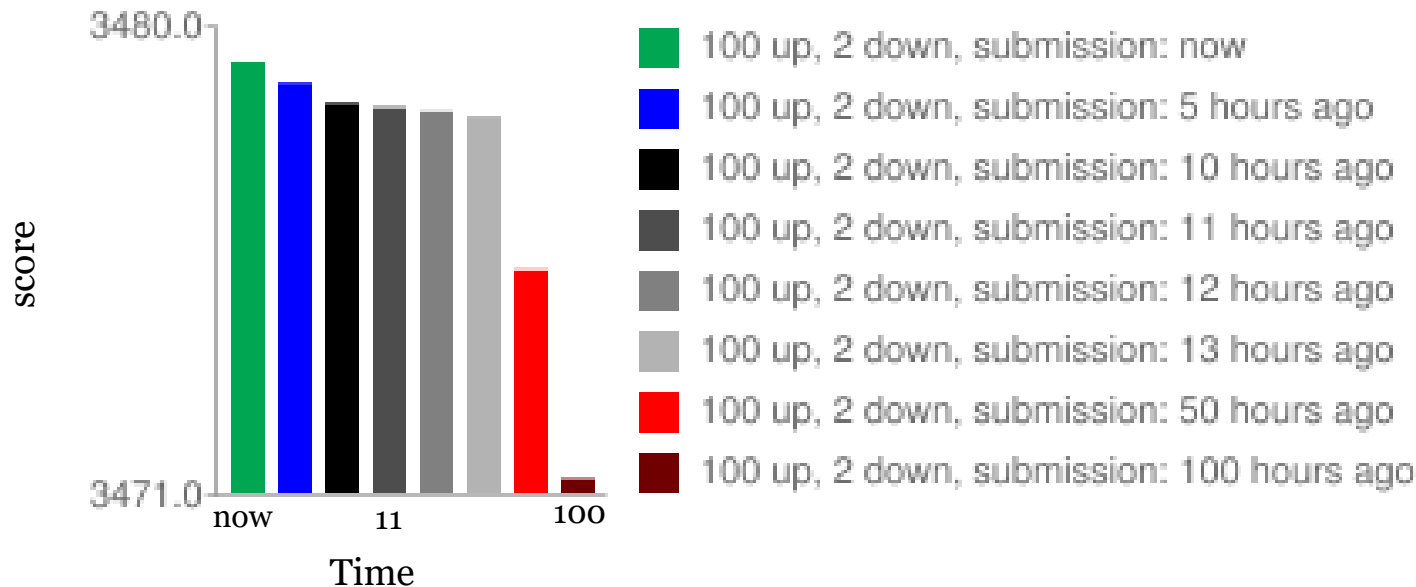
$$y = \begin{cases} 1 & \text{if } x > 0 \\ 0 & \text{if } x = 0 \\ -1 & \text{if } x < 0 \end{cases}$$



The graph of $y = \log_{10}(x)$

Effect of #upvote

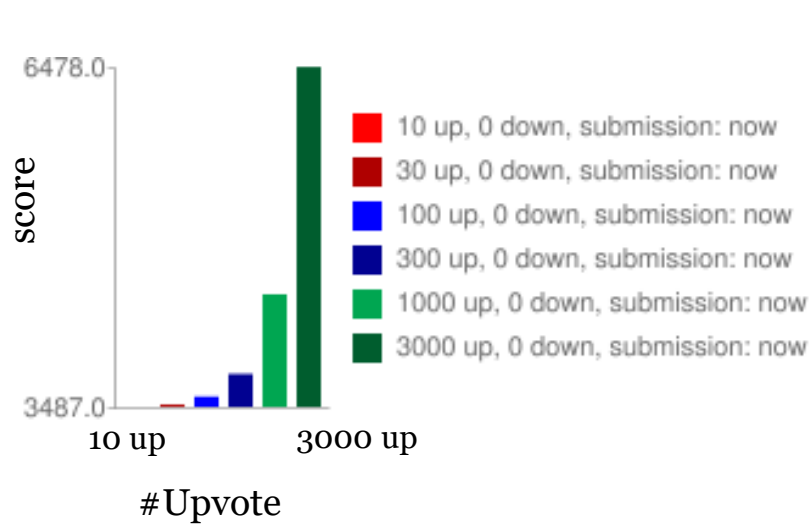
Effects of Submission Time



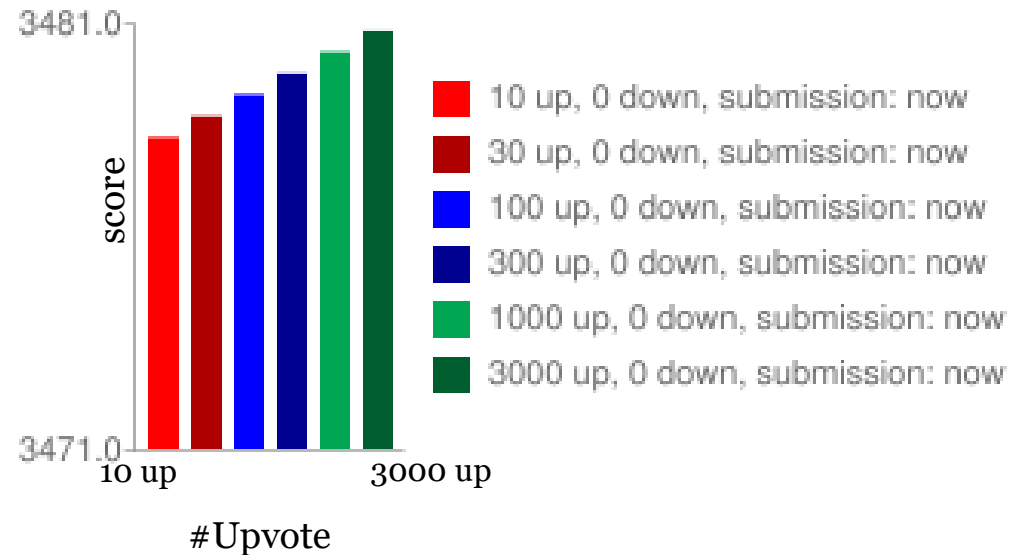
- Submission time is **significant to ranking** (the newer stories the higher rank is.)
- Newer stories has a **higher score** than older.

The Effect of Using Logarithm Scale on The Calculated Point (Votes)

Without using the logarithm scale



Using the logarithm scale



More about Reddit

- How Reddit ranking algorithms work
 - <https://medium.com/hacking-and-gonzo/how-reddit-ranking-algorithms-work-ef111e33d0d9#.bj4fokhfm>
- Reddit dataset:
 - https://www.reddit.com/r/datasets/comments/3mg812/full_reddit_submission_corpus_now_available_2006/

Outlines

- Weak Points of Non-Personalized RS
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- Scoring and Ranking
- **Basic Similarity Measures**

What is Similarity?

- Given 2 feature (attribute) vectors, similarity is a measure how two vectors are similar.

Name\Movie	Zootopia	Superman	Star Trek Beyond	The Angry Bird Movie	Ghost Busters
Ann	Yes		Yes		Yes
Pete	Yes	Yes	Yes	Yes	Yes
Kate		Yes	Yes		
Jason		Yes	Yes	Yes	

- $\text{sim}(x, y) = ?$

Basic Similarity Measures

- **Confidence** (Association Rule Mining)
 - **Asymmetric** measure
 - Measure how likely a user is to rate one given that they rated the other
 - $\text{sim}(\mathbf{x}, \mathbf{y}) = (\text{items}_{\mathbf{x}} \cap \text{items}_{\mathbf{y}}) / \text{items}_{\mathbf{x}}$
 - Example:
 - $\text{sim}(\text{Ann}, \text{Pete}) = 3/3 = 1$
 - $\text{sim}(\text{Pete}, \text{Ann}) = 3/5 = 0.6$
 - $\text{sim}(\text{Kate}, \text{Jason}) = 2/2 = 1$
 - $\text{sim}(\text{Jason}, \text{Kate}) = 2/3 = 0.67$

Name\ Movie	Zoo-topia	Super man	Star Trek Beyond	The Angry Bird Movie	Ghost Busters
Ann	Yes		Yes		Yes
Pete	Yes	Yes	Yes	Yes	Yes
Kate		Yes	Yes		
Jason		Yes	Yes	Yes	

Jaccard Coefficient

- Measure the overlap that x and y share with their attributes.
- $\mathbf{J} = \mathbf{M}_{11} / (\mathbf{M}_{01} + \mathbf{M}_{10} + \mathbf{M}_{11})$
- where,
 - \mathbf{M}_{11} = the total number of attributes where x and y both have a value of 1.
 - \mathbf{M}_{01} = the total number of attributes where the attribute of x is 0 and the attribute of y is 1.
 - \mathbf{M}_{10} = the total number of attributes where the attribute of x is 1 and the attribute of y is 0.

Jaccard Coefficient's Example

- $\text{sim}(\text{Ann}, \text{Pete}) = \text{sim}(\text{Pete}, \text{Ann}) = 3/5 = 0.6$
- $\text{sim}(\text{Kate}, \text{Jason}) = \text{sim}(\text{Jason}, \text{Kate}) = 2/3 = 0.67$
- *Equivalent to*
 - $\text{sim}(x, y) = (\text{items}_x \cap \text{items}_y) / (\text{items}_x \cup \text{items}_y)$

Name\ Movie	Zoo- topia	Super man	Star Trek Be- yond	The Angry Bird Movie	Ghost Bust- ers
Ann	Yes		Yes		Yes
Pete	Yes	Yes	Yes	Yes	Yes
Kate		Yes	Yes		
Jason		Yes	Yes	Yes	

Practice 2-1

1. Create a dataset D1 of all students in class with ratings of the 3 selected movies (scaling 1-5)
2. Calculate scores of the 3 movies in D1 using **Damped Mean**
3. Rank items based on the ranking method specified in Q2.
4. Link to edit the dataset D1 is provided in MS Teams' channel.

Practice 2-2

1. Create a dataset D2 of all students in class with upvote (U) or downvote (D)
 2. Calculate scores of the 5 topics in D2 using
[Hacker News Ranking Algorithm](#)
 3. Rank items based on the ranking method in Q1.
-
1. Link to edit the dataset D2 is provided in MS Teams' channel.