

From Preference into Decision Making

Modeling User Interactions in Recommender
Systems

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Recommender Systems

- Most prior research focuses on
 - Learning from user action feedback (e.g., ratings or clicks etc.)
- This work is about
 - Learning from all user browsing (both user action and inaction) activities

Explicit/Implicit Feedback and Preference

What about other (inaction) items?

The screenshot shows the 'top picks' section of the MovieLens website. It features a grid of movie cards, each with a poster, title, year, rating, and runtime. The cards are arranged in three rows. Annotations include:

- Red circles:** One around the 'Add into a wishlist' button on 'The Godfather' card, and another around the 'undo' button on a message box that says 'this movie will not appear in most search results' over the 'Fight Club' card.
- Red arrows:** Three arrows pointing from the text 'What about other (inaction) items?' to the 'Add into a wishlist' button, the 'undo' button, and the 'Click to see details' button.
- Text annotations:** 'Add into a wishlist' (in red), 'Not interested' (in red), and 'Rating' (in red) are placed over the interface.
- Star ratings:** Each card has a star rating below it. Some ratings are circled in red, such as the 5-star rating for 'The Godfather' and the 5-star rating for 'Zootopia'.

Key Missing Factor

- Within page comparison
- Decision of action vs. inaction

Click to see details

Explicit/Implicit Feedback and Preference

What if this is the 3rd time the user sees this page?

The screenshot shows the 'top picks' section of the MovieLens website. It features a grid of movie cards, each with a poster, title, year, rating, and a star rating. Annotations include:

- Add into a wishlist:** A red circle around the 'Add to wishlist' icon on the 'The Godfather' card.
- Not interested:** A red circle around a message box that says 'this movie will not appear in most search results' with an 'undo' button, located over the 'Fight Club' card.
- Click to see details:** A red circle around the 'Gran Torino' card.
- Rating:** Red circles around the star ratings for 'Zootopia' (5 stars) and 'Inside Out' (5 stars).

Key Missing Factor

- Temporal dependency to prior browsing





Example Impact on User Experience

MovieLens

MovieLens recommends these movies

top picks

view: filters: rated movies: hide ▾ more ▾





<p>The Avengers ⚙ ×</p> <p>2012 PG-13 143 min</p>  <p>★★★★★</p>	<p>Skyfall ⚙ ×</p> <p>2012 PG-13 143 min</p>  <p>★★★★★</p>	<p>Big Hero 6 ⚙ ×</p> <p>2014 • 102 min</p>  <p>★★★★★</p>	<p>Die Hard ⚙ ×</p> <p>1988 R 131 min</p>  <p>★★★★★</p>
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Again and Again

MovieLens recommends these movies

top picks

view: filters: rated movies: hide more

<p>The Avengers <input type="checkbox"/> <input type="checkbox"/></p> <p>2012 <input type="checkbox"/> PG-13 143 min</p>  <p><input type="checkbox"/> ★★★★★</p>	<p>Skyfall <input type="checkbox"/> <input type="checkbox"/></p> <p>2012 <input type="checkbox"/> PG-13 143 min</p>  <p><input type="checkbox"/> ★★★★★</p>	<p>Big Hero 6 <input type="checkbox"/> <input type="checkbox"/></p> <p>2014 • 102 min</p>  <p><input type="checkbox"/> ★★★★★</p>	<p>Die Hard <input type="checkbox"/> <input type="checkbox"/></p> <p>1988 <input type="checkbox"/> R 131 min</p>  <p><input type="checkbox"/> ★★★★★</p>
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Youtube

The image shows a screenshot of the YouTube homepage. At the top, there is a search bar with the text "Search" and a magnifying glass icon. To the right of the search bar are icons for video uploads, a grid, a play button, a bell, and a profile picture. Below the search bar, the word "Recommended" is displayed. The main content area features a grid of video thumbnails. Each thumbnail includes a video player preview, a duration in the bottom right corner, and a title below it. The first row contains five videos: "Peppa Pig English Full Episodes Compilation #116" (1:03:00), "We Are the Princesses | Humpty Dumpty +More Kids..." (20:28), "MOANA: How Far I'll Go Song (2016)" (2:39), "Frozen - Best Moments" (15:31), and "Peppa Pig Full Episodes - George the Dinosaur..." (41:52). The second row contains five videos: "Peppa Pig English Episodes | Peppa Pig's Magical Castle |..." (1:08:57), "Moana Full Movie in English - Disney Animation Movie HD" (1:36:50), "Peppa Pig English Season 2 Episode 24 George Catches..." (4:30), "Peppa Pig 109 The Camper Van" (4:30), and "Peppa Pig English Episodes | Peppa's Magical Castle! |..." (1:08:57). Each video title is followed by the channel name and view/viewer statistics.

Recommended

Peppa Pig English Full Episodes Compilation #116
Peppa Pig English
4.3M views · 4 months ago

We Are the Princesses | Humpty Dumpty +More Kids...
Little Angel: Nursery Rhymes &...
14M views · 10 months ago

MOANA: How Far I'll Go Song (2016)
KinoCheck International ©
11M views · 1 year ago

Frozen - Best Moments
Captain Kevin ©
1.9M views · 3 weeks ago

Peppa Pig Full Episodes - George the Dinosaur...
Peppa Pig - Official Channel ©
27M views · 1 year ago

Peppa Pig English Episodes | Peppa Pig's Magical Castle |...
Peppa Pig Asia
104K views · 1 week ago

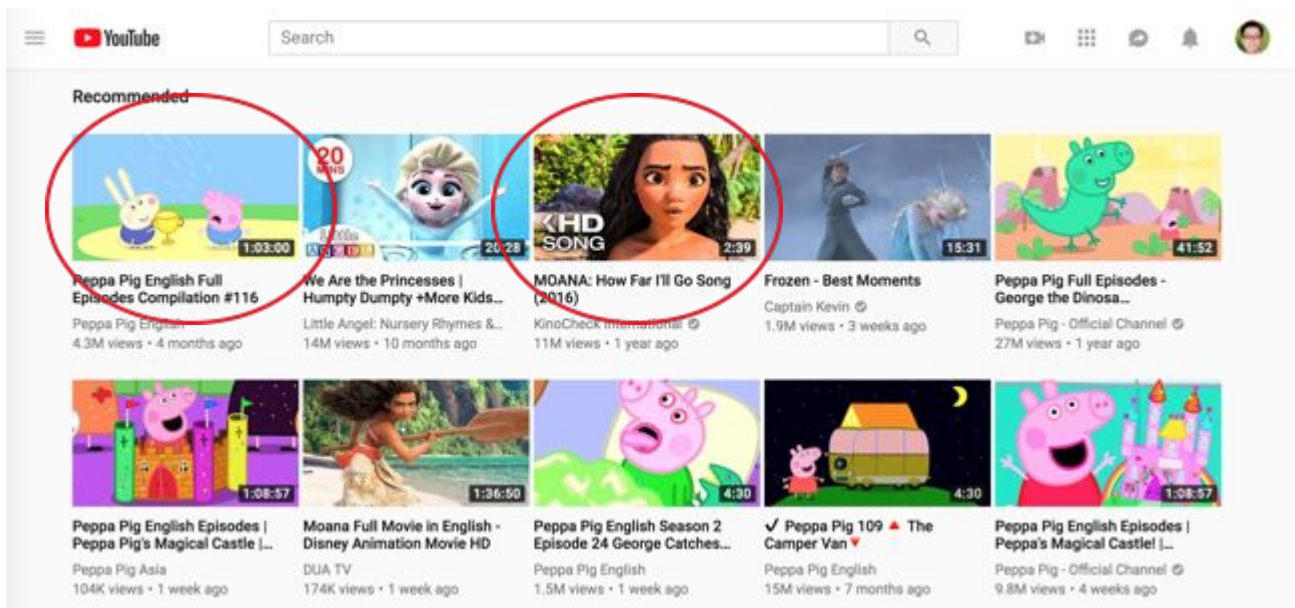
Moana Full Movie in English - Disney Animation Movie HD
DUA TV
174K views · 1 week ago

Peppa Pig English Season 2 Episode 24 George Catches...
Peppa Pig English
1.5M views · 1 week ago

✓ Peppa Pig 109 The Camper Van
Peppa Pig English
15M views · 7 months ago

Peppa Pig English Episodes | Peppa's Magical Castle! |...
Peppa Pig - Official Channel ©
9.8M views · 4 weeks ago

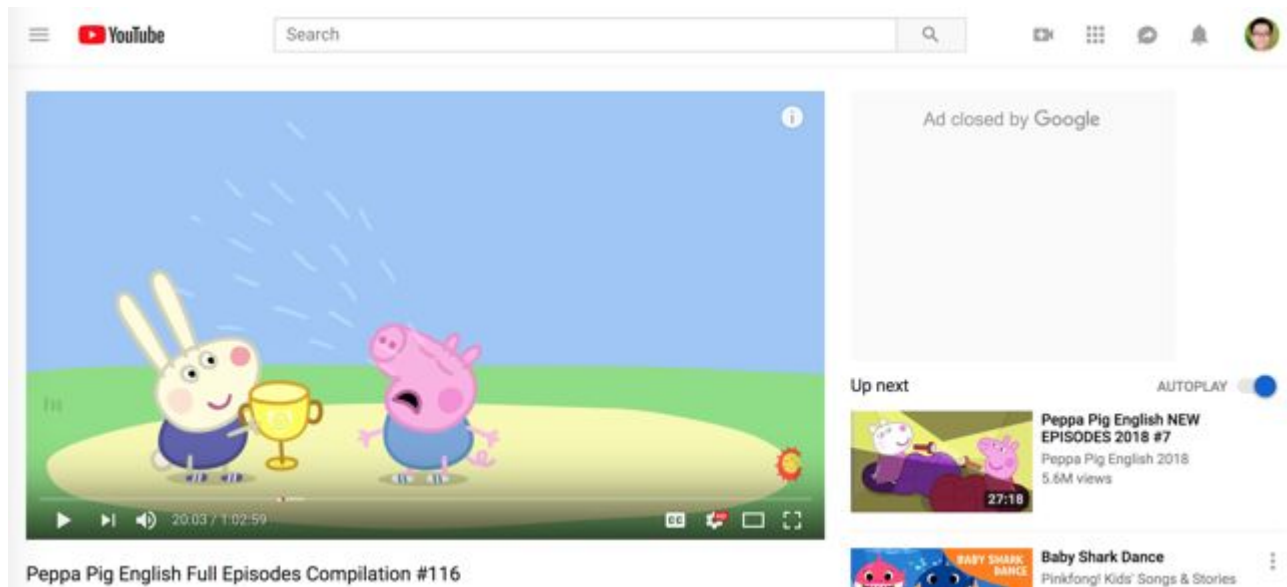
Interested in two of them



The image shows a screenshot of a YouTube 'Recommended' video grid. Two video thumbnails are circled in red: 'Peppa Pig English Full Episodes Compilation #116' and 'MOANA: How Far I'll Go Song (2016)'. The grid contains ten video thumbnails in two rows of five. Each thumbnail includes a video preview, a duration, a title, a channel name, and view/age information.

Thumbnail	Title	Channel	Views	Age
1 (Circled)	Peppa Pig English Full Episodes Compilation #116	Peppa Pig English	4.3M	4 months ago
2	We Are the Princesses Humpty Dumpty +More Kids...	Little Angel: Nursery Rhymes &...	14M	10 months ago
3 (Circled)	MOANA: How Far I'll Go Song (2016)	KinoCheck International	11M	1 year ago
4	Frozen - Best Moments	Captain Kevin	1.9M	3 weeks ago
5	Peppa Pig Full Episodes - George the Dinosaur...	Peppa Pig - Official Channel	27M	1 year ago
6	Peppa Pig English Episodes Peppa Pig's Magical Castle ...	Peppa Pig Asia	104K	1 week ago
7	Moana Full Movie in English - Disney Animation Movie HD	DUA TV	174K	1 week ago
8	Peppa Pig English Season 2 Episode 24 George Catches...	Peppa Pig English	1.5M	1 week ago
9	✓ Peppa Pig 109 ▲ The Camper Van	Peppa Pig English	15M	7 months ago
10	Peppa Pig English Episodes Peppa's Magical Castle! ...	Peppa Pig - Official Channel	9.8M	4 weeks ago

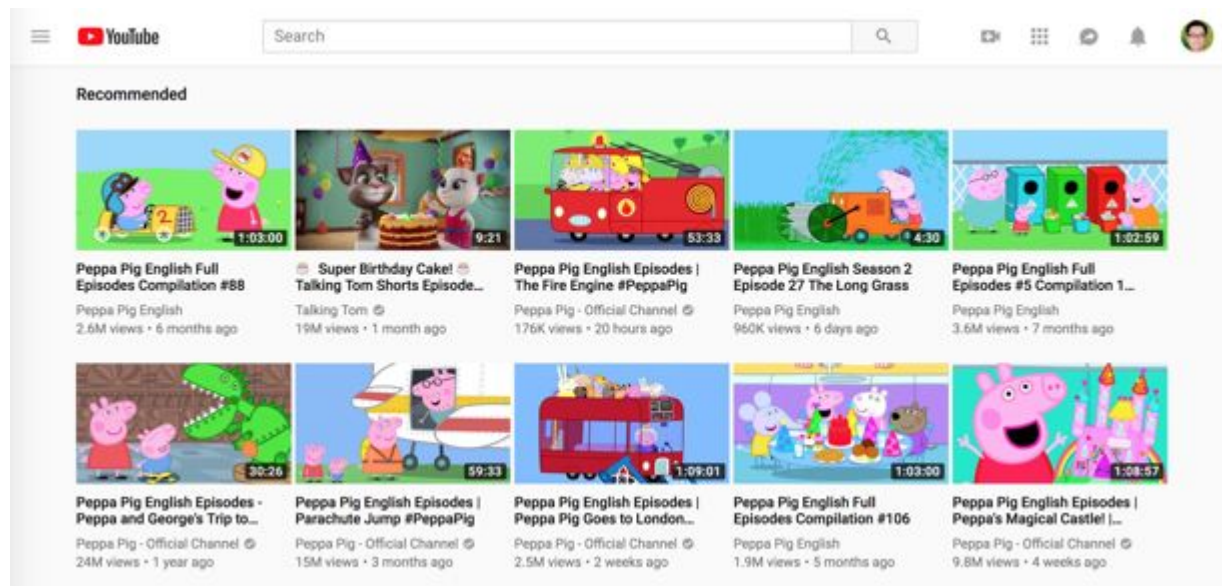
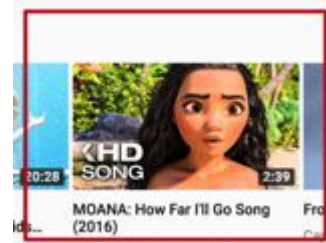
Watch one of the two



The image shows a YouTube video player interface. The main video frame displays two cartoon characters, a white rabbit and a pink pig, on a green field under a blue sky. The rabbit is holding a golden trophy, and the pig is looking at it with an open mouth. The video player includes a search bar at the top, a play button, a progress bar showing 20:03 / 1:02:59, and a volume icon. Below the video player, the title "Peppa Pig English Full Episodes Compilation #116" is visible. To the right of the video player, there is a placeholder for an advertisement that says "Ad closed by Google". Below the ad, there is an "Up next" section with two video thumbnails. The first thumbnail is for "Peppa Pig English NEW EPISODES 2018 #7" with 5.6M views and a duration of 27:18. The second thumbnail is for "Baby Shark Dance" by Pinkfong! Kids' Songs & Stories.

Zhao et al. *RecSys'18*

Back to home page...?



Problem

- How to model all user browsing activities jointly?
 - Temporal browsing (viewing recommendation lists and/or searching/filtering) page by page
 - Action (performing actions on recommended items, e.g., clicking, consuming) on a page
 - Inaction (neglecting or skipping recommended items) on a page

Decision Field Theory

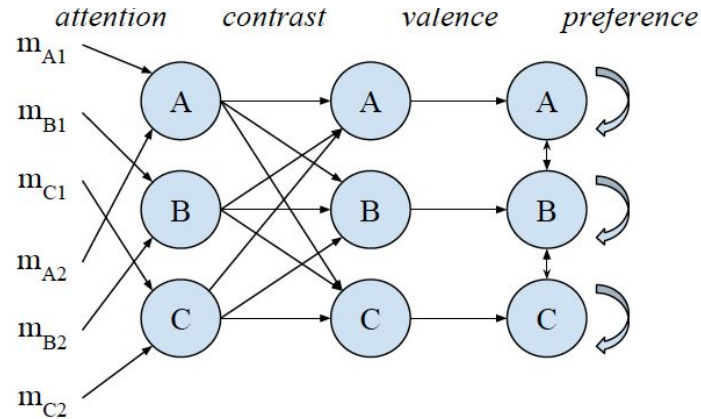


Figure 1: The connectionist network representation of DFT.

Decision Field Theory

Preference is actually the end result of micro-level decision making processes.

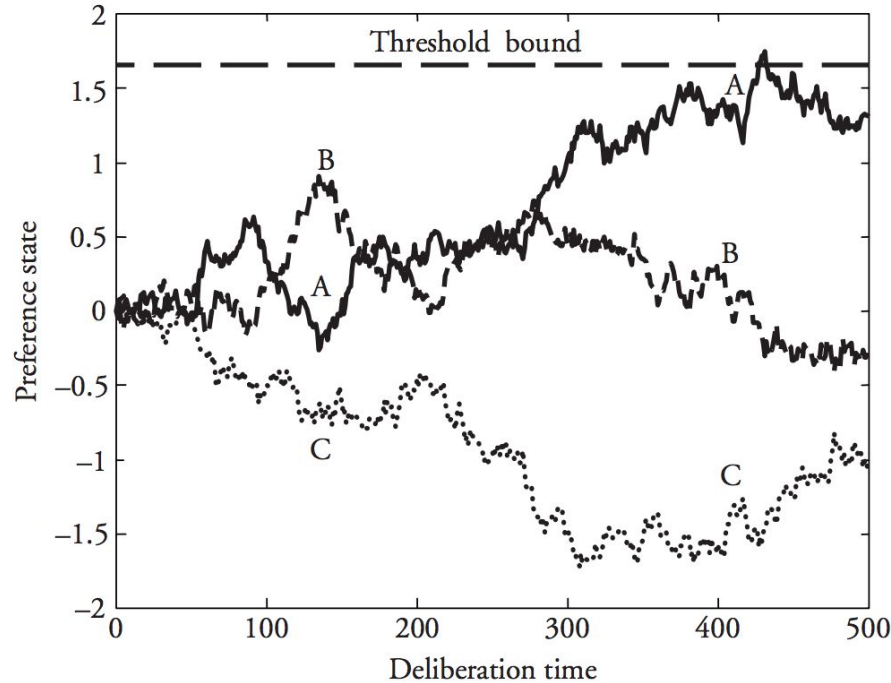
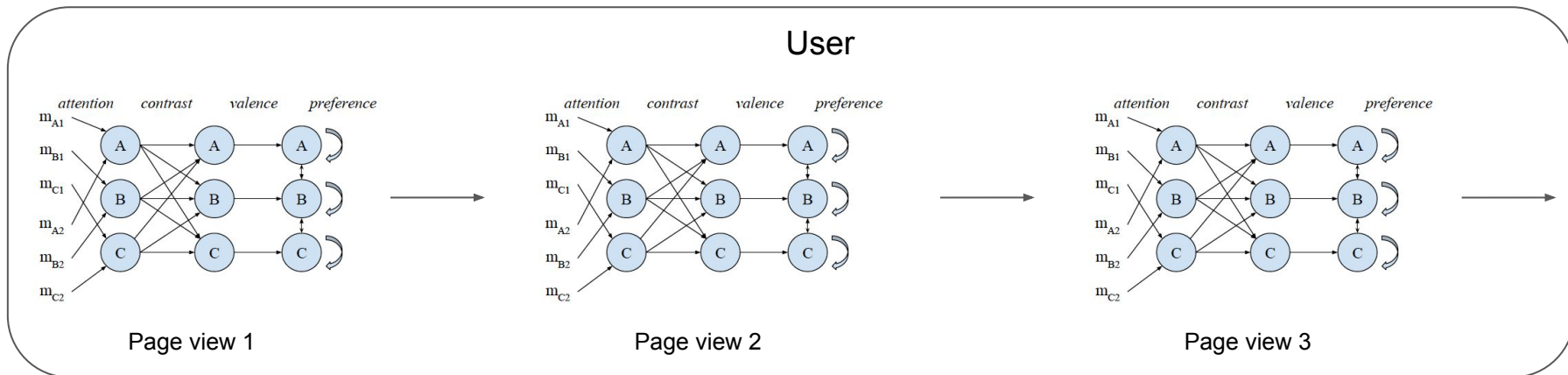


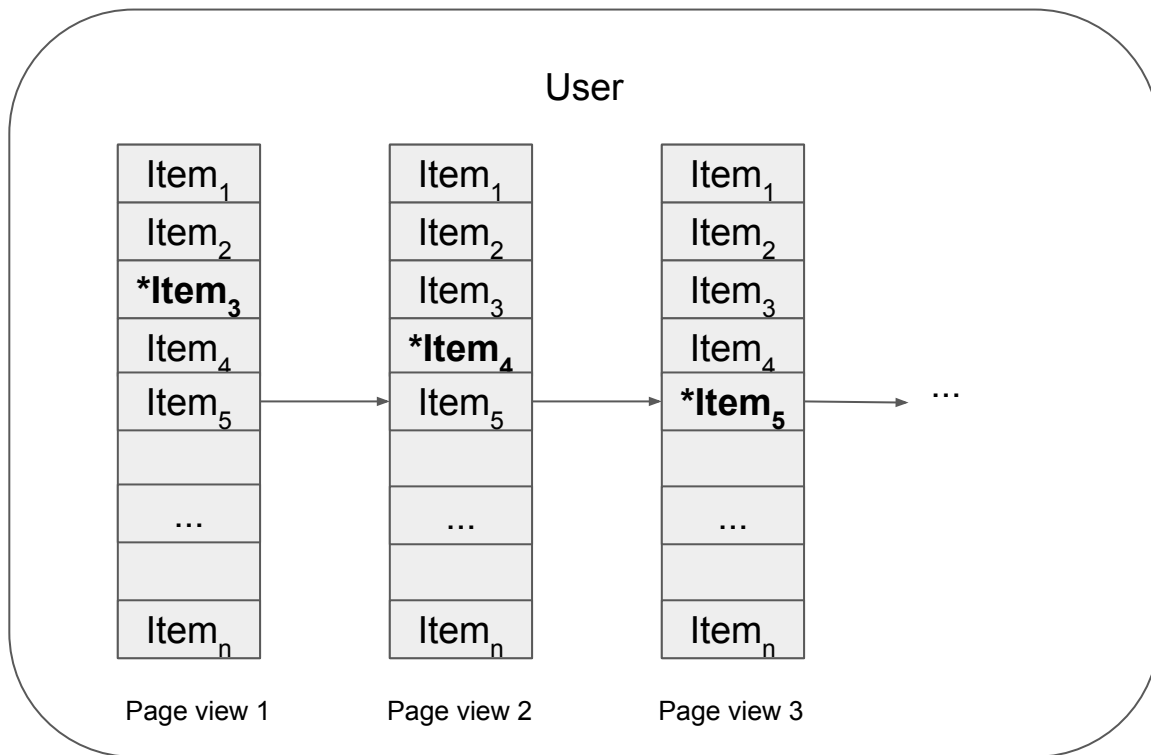
Figure 7.1 The decision process for a choice among three actions

The Page-Level RNN Model



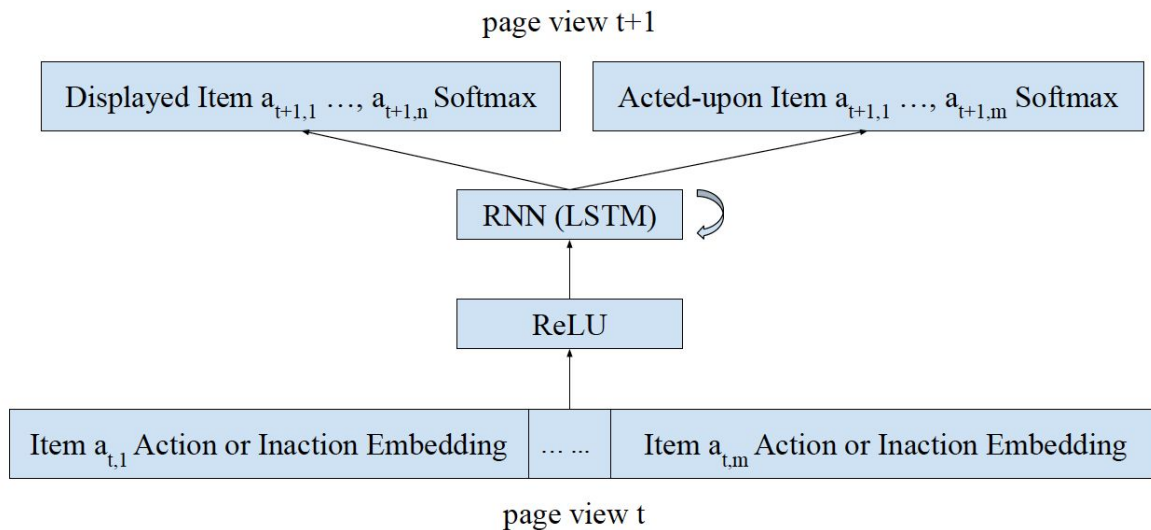
- Learn embeddings instead of using attributes
- Weights are estimated from data
- Page view sequence as the deliberation process
- There are actually 24 items because of the page size in MovieLens.
- Contrast layer is a ReLU layer
- Preference accumulation corresponds to a RNN layer

The Page-Level RNN Model



We used $n=24$ because of the page size in MovieLens.

The Page-Level RNN Model

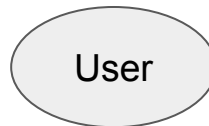


Dataset: MovieLens System Logs

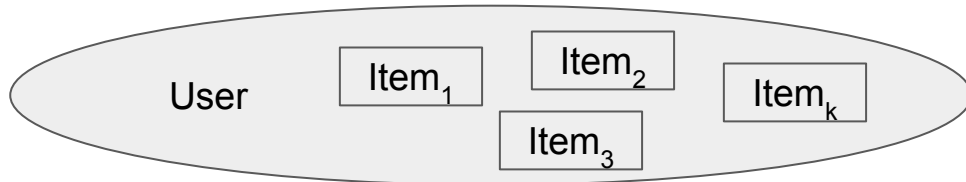
- Jan. 12, 2017 to Jan. 14, 2018
- 60K movies
- 22K users
- 45M movie displays and 1.16M (positive) actions
- Temporal splitting
 - Training: Jan. 12, 2017 to Oct. 31, 2017
 - Testing: Nov. 1, 2017 to Jan. 14, 2018

Classical *User* & Preference Models

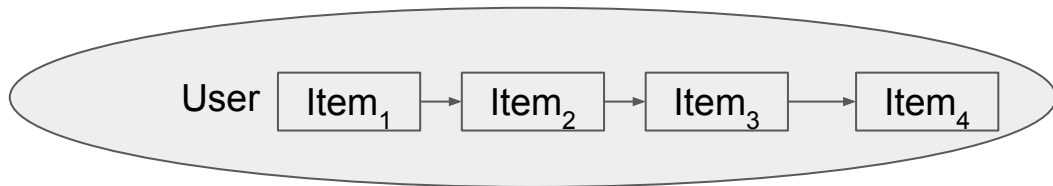
- SVD (Koren et al. 2009):



- SVD++ (Koren et al. 2010):



- RNN (Wu et al. 2017):



Results

User Model	MAP@8
SVD	0.097
SVD++	0.106
RNN	0.119
PL-RNN	0.141

Modeling user actions as a sequence through RNN seems to learn a better user representation compared with SVD or SVD++

Page-level RNN gains substantially better accuracy than RNN.

Classical User & *Preference* Models

- Independent binary (logistic; Hu et al. 2008):

$$\widehat{p}(r|u, v) = g^r (1 - g)^{1-r}$$

- Competitive (softmax; Yang et al. 2011, CCF): $\widehat{p}(a|u, v) = \widehat{p}_a(a_i = 1|u, v) = \frac{\exp(f(s, o_i))}{\sum_{k=1}^{\alpha+1} \exp(f(s, o_k))}$

- Relative (pairwise ranking; Rendle et al. 2009):

$$p(r_a > \widehat{r}_b | u, v_a, v_b) = g(f(s, o(v_a) - o(v_b)))$$

“*Negative*” Items

- Negative sampling (Hu et al. 2009)
- Displayed but inaction (Yang et al. 2011; Zhao et al. 2018)

Results (MAP@8)

User Model	Preference Model	Displayed but Inaction “Negative”	Sampled “Negative”
SVD	logistic	0.0006	0.104
	softmax	0.0006	0.097
	pairwise ranking	0.114	0.106

Softmax and logistic preference models are sensitive to the choice of negative items.

Pairwise preference models can learn equally well on both types of negative items.

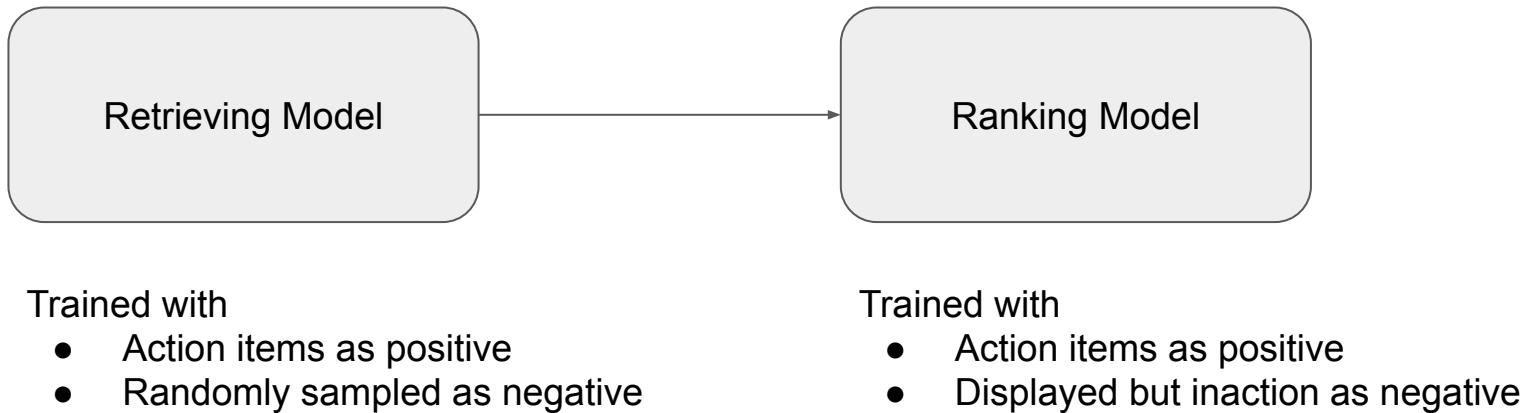
Messages

- Jointly modeling the three aspects (temporal browsing, action and inaction) of user-system interaction in recommender systems has benefits in
 - (this work) offline recommendation accuracy
 - (maybe, future work) online user experience
- Go from simplified preference assumptions into modeling the complex micro-level user decision making processes.

Thanks! Questions?

- Title: “From Preference into Decision Making: Modeling User Interactions in Recommender Systems”
- Authors: Qian Zhao, Martijn C. Willemsen, Gediminas Adomavicius, F. Maxwell Harper, and Joseph A. Konstan.
- Contact: qzhao2018@gmail.com

Hybrid Based on *Retrieving & Ranking*



Results

User Model	Preference Model	“Negative” Items	MAP@8
SVD	softmax	sampled	<i>0.097</i>
SVD++			<i>0.106</i>
RNN			<i>0.119</i>
RNN & SVD	softmax & pairwise	sampled & displayed but inaction	<i>0.140</i>
PL-RNN	softmax	sampled & displayed but inaction	<i>0.141</i>