

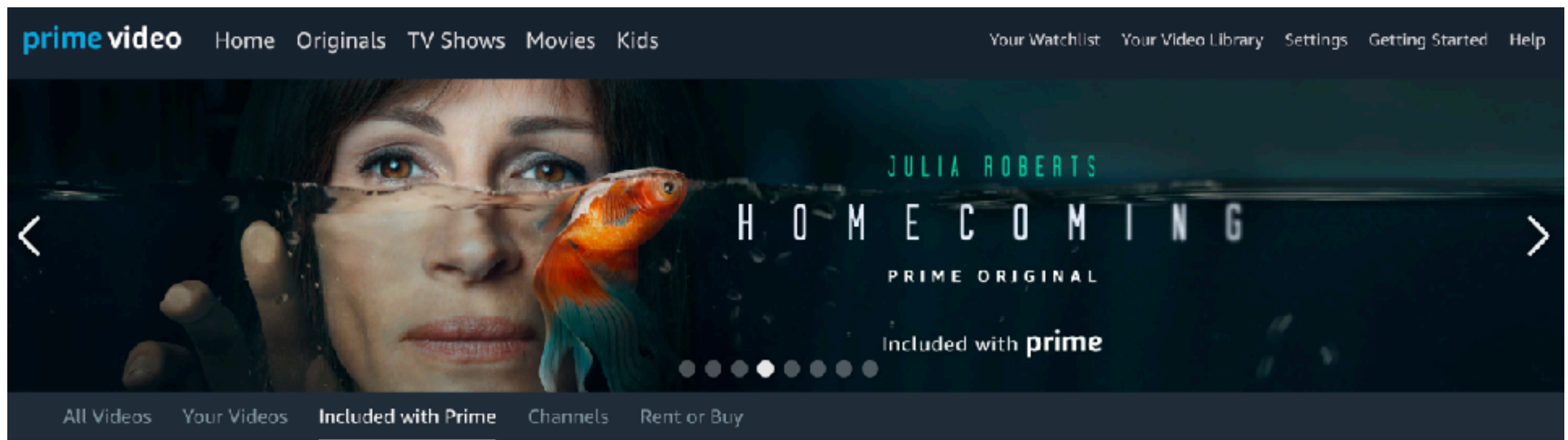
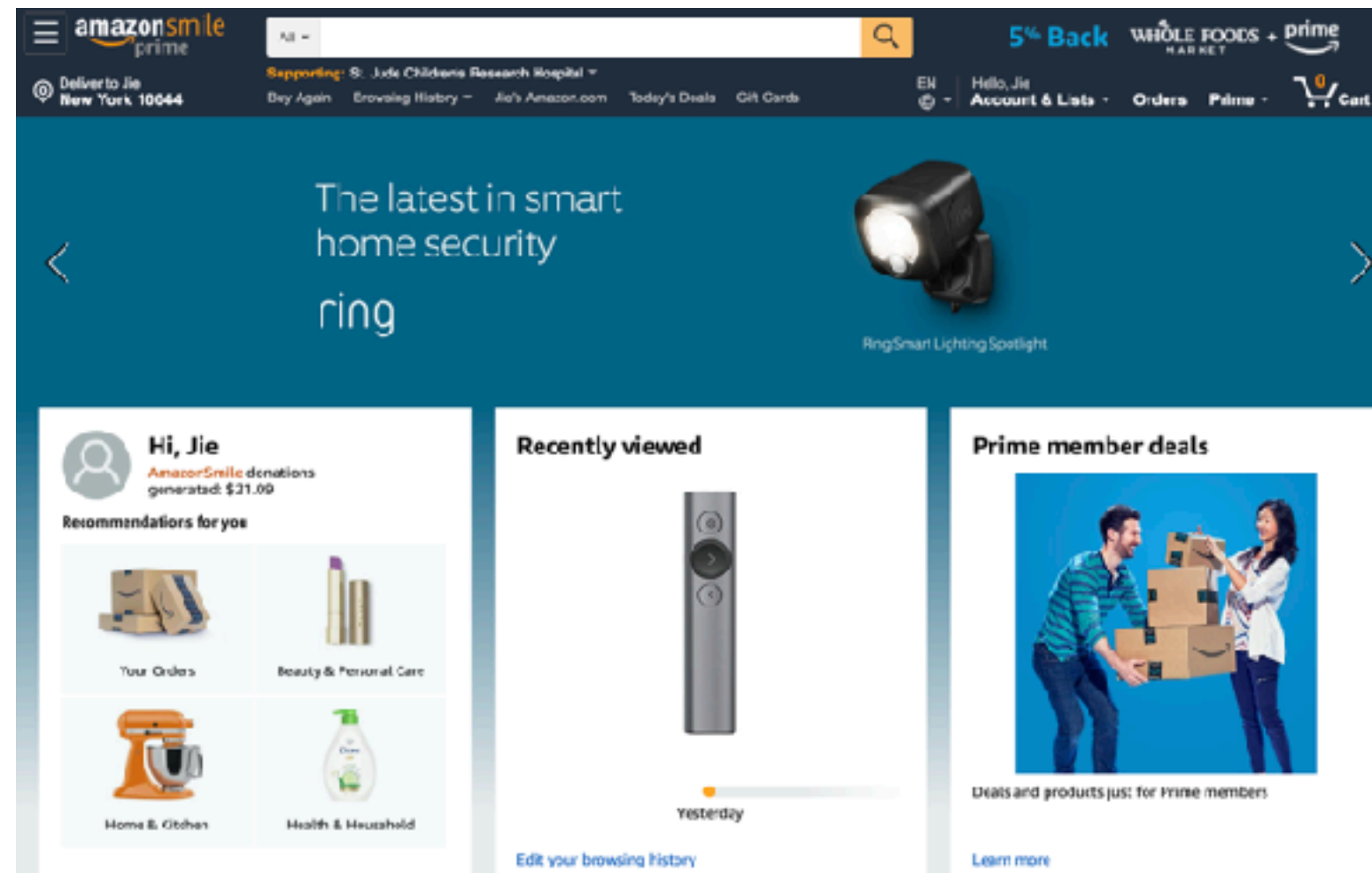
Artificial Intelligence

Instructor: Jie Shen

Department of Computer Science

Background

2



amazon smile

Delivered Jan 12, 2019



Oral-B White Pro 1000 Power Rechargeable Electric Toothbrush, Powered by Braun

Sold by: Amazon.com Services, Inc

Return window closed on Feb 11, 2019

\$39.94

Buy it again

Get product support

Order details

Write a product review

Archive order



10 Braun Oral-B Cross Action Replacement Toothbrush Heads by Oral-B
by Oral-B

★★★★★ ~ 106

\$36.99

✓prime | FREE One-Day.



Oral-B FlossAction Electric Toothbrush Replacement Brush Heads Refill (2 count)
by Oral-B

★★★★★ ~ 2,886

\$14.88 ~~\$17.15~~

Save 5% more with Subscribe & Save

✓prime | FREE One-Day.



Toothbrush Replacement Heads Refill for Oral-B Electric Toothbrush, 4 Floss Action, 4 cross action, 8 Count
by MelMel

★★★★★ ~ 95

\$10.89

Save 5% with coupon

✓prime | FREE One-Day.

Rating System: 1 Star - 5 Stars

4

amazon

prime

Books ▾ probability theory

5% Back

WHOLE FOODS + prime

Deliver to Jie
New York 10044

Buy Again

Browsing History ▾

Jie's Amazon.com

Today's Deals

EN

Hello, Jie

Account & Lists ▾

Orders

Prime ▾

0 Cart

Books

Advanced Search

New Releases

Amazon Charts

Best Sellers & More

The New York Times® Best Sellers

Children's Books

Textbooks

Textbook Rentals

1-16 of over 2,000 results for Books : 4 Stars & Up : "probability theory"

Sort by: Featured ▾

Amazon Prime

☐ prime

☐ prime | FREE One-Day

Get FREE One-Day Shipping on qualifying orders over \$35

Delivery Day

☐ Get It by Tomorrow

Department

< Any Department

Books

Probability & Statistics

Mathematics

Mathematical Physics

Science & Math

Physics

Technology

Economics

Finance

Schools & Teaching

Calculus

> See more

Avg. Customer Review

< Clear

★★★★★ & Up

★★★★☆ & Up

★★★☆☆ & Up

★★☆☆☆ & Up

Introduction to
Probability
Statistics and Random Processes
Hossein Pishro-Nik







Sponsored ⓘ
Introduction to Probability, Statistics, and Random Processes
by Hossein Pishro-Nik | Aug 24, 2014
★★★★☆ ~ 42
Paperback
\$38⁵⁰
Save \$2.36 with No-Rush Shipping
prime FREE delivery by Sun, Mar 17

LECTURES ON
PROBABILITY THEORY
AND MATHEMATICAL
STATISTICS
3RD EDITION
MARCO TABOGA

Sponsored ⓘ
Lectures on Probability Theory and Mathematical Statistics - 3rd Edition
by Marco Taboga | Dec 8, 2017
★★★★☆ ~ 4
Paperback
\$49²⁴ ~~\$65.50~~
prime FREE delivery by Sun, Mar 17

Probability Theory
The Logic of Science

Probability Theory: The Logic of Science
by E. T. Jaynes and G. Larry Bretthorst | Jun 9, 2003
★★★★☆ ~ 43

AllIMDbPro Help    


[Watch Now For Free](#) [Movies, TV & Showtimes](#) [Celebs, Events & Photos](#) [News & Community](#) [Watchlist](#) [Sign in](#)















IMDb Charts

Top Rated Movies

Top 250 as rated by IMDb Users

Showing 250 Titles

Sort by: Ranking 

Rank & Title	IMDb Rating	Your Rating	
 1. The Shawshank Redemption (1994)	★ 9.2	☆	
 2. The Godfather (1972)	★ 9.2	☆	
 3. The Godfather: Part II (1974)	★ 9.0	☆	
 4. The Dark Knight (2008)	★ 9.0	☆	
 5. 12 Angry Men (1957)	★ 8.9	☆	
 6. Schindler's List (1993)	★ 8.9	☆	
 7. The Lord of the Rings: The Return of the King (2003)	★ 8.9	☆	

You Have Seen

0/250 (0%)

☐ Hide titles I've seen

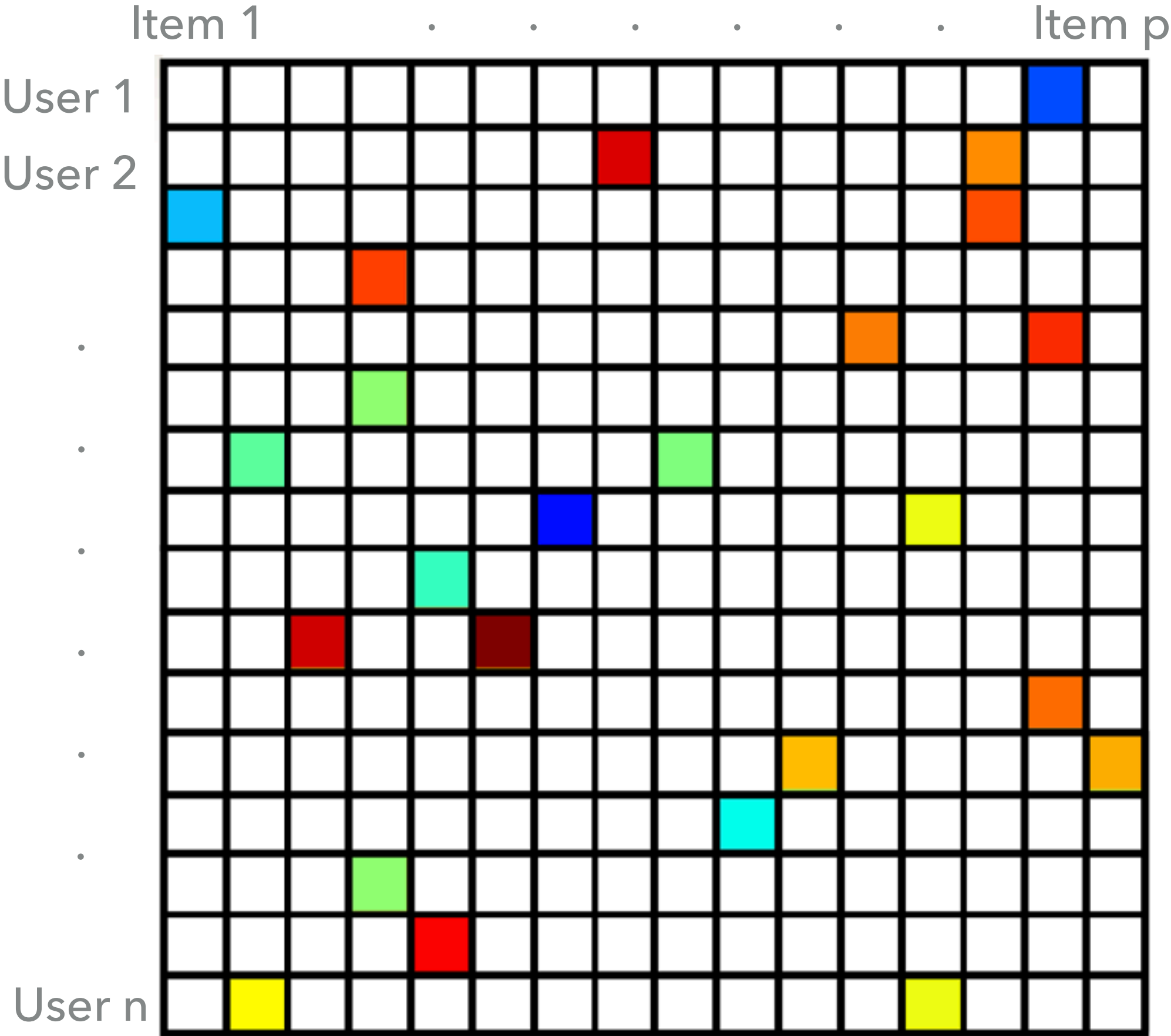
IMDb Charts

- [Box Office](#)
- [Most Popular Movies](#)
- [Top Rated Movies](#)
- [Top Rated English Movies](#)
- [Most Popular TV](#)
- [Top Rated TV](#)
- [Top Rated Indian Movies](#)
- [Lowest Rated Movies](#)

Top Rated Movies by Genre

- [Action](#)
- [Adventure](#)
- [Animation](#)
- [Biography](#)
- [Comedy](#)
- [Crime](#)
- [Drama](#)
- [Family](#)
- [Fantasy](#)
- [Film-Noir](#)
- [History](#)
- [Horror](#)
- [Music](#)

"Real-Valued" Data

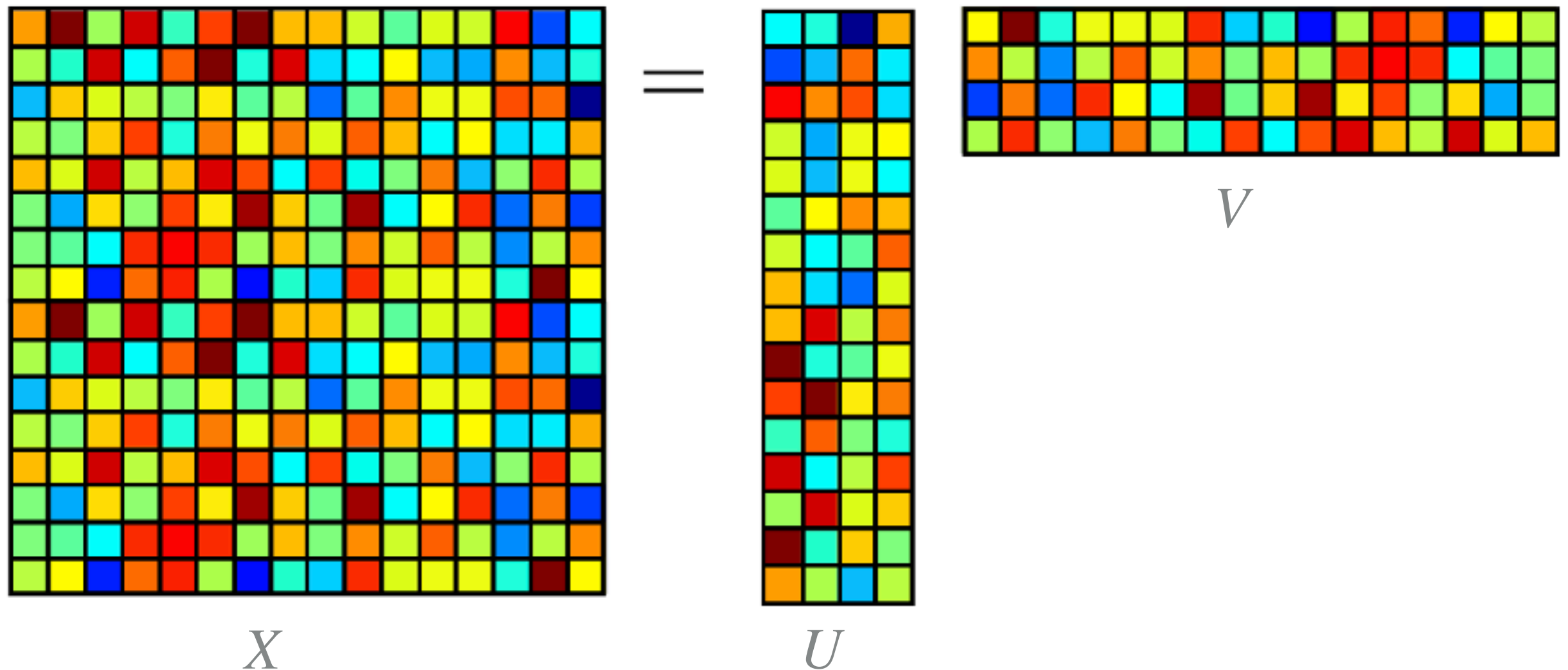


Collaborative Filtering for 1 - 5 Rating

7

- ▶ Traditional collaborative filtering (CF):

$$\min_X \|(Z - X)_\Omega\|_F^2, \quad \text{s.t. rank}(X) \leq r$$



- ▶ CF:
$$\min_{U,V} \|(Z - UV^\top)_\Omega\|_F^2 + \lambda(\|U\|_F^2 + \|V\|_F^2)$$

What's the Problem?

8

Customer reviews

★★★★★ 8

5.0 out of 5 stars

5 star	<div></div>	100%
4 star	<div></div>	0%
3 star	<div></div>	0%
2 star	<div></div>	0%
1 star	<div></div>	0%



Linear Operator Theory in Engineering and Science (Applied Mathematical Sci...

by Arch W. Naylor

Format: Paperback | [Change](#)

Price: \$117.56 ✓prime

[Write a review](#)

[Look inside](#)



Char

★★★★★ i would give 6 stars!

February 26, 2012

Format: Paperback | **Verified Purchase**

I'm doing a PhD in econometrics and I need to apply operator theories in constructing a linear or nonlinear operator to help explain individual economic behaviour. This book contains numerous useful ideas and applications with exercises thoroughly designed; one of the questions in the exercise gave me an idea of creating a matrix for describing a nonlinear operator. That question asks for a matrix that describes a second order differential operator and that gave me an idea that taylor series approximation can be used to linearise a nonlinear operator and hence a nonlinear operator may also be described by a matrix.



Lorenzo Martin

★★★★★ **Actually impressed.**

October 17, 2018

Color: Heather Gray | Configuration: Echo Dot | **Verified Purchase**

I was debating between this and the regular echo. I've had both and we both know what the echo does so all I'll talk about is the sound quality.

I'm going to get to the chase. This is the BEST speaker I've ever heard for under \$50. The functions of the echo along with the music playing functionality and the sound quality makes it a steal at this price point.

The sound is great for its size. It can get pretty loud but the bass is definitely lacking. The bass isn't god awful but it just isn't there.

Now I will say this... if your primary motivation for a speaker is to listen to music, go with the echo. If it is but your budget is under \$50 then go with the dot. It won't blow anyone away during a get together in your living room but it'll get the job done. The dot will only flourish in an enclosed space. It needs walls nearby to bounce off to cover up the weakness of the bass.

If I had to compare the sound to another speaker, I'd say the UE Wonderboom or the older Beats Pill, all of which suffer from weak bass. For the size, I was impressed by the sound but with the Echo at its refurbished price of \$69 I'll have to aim towards that direction.

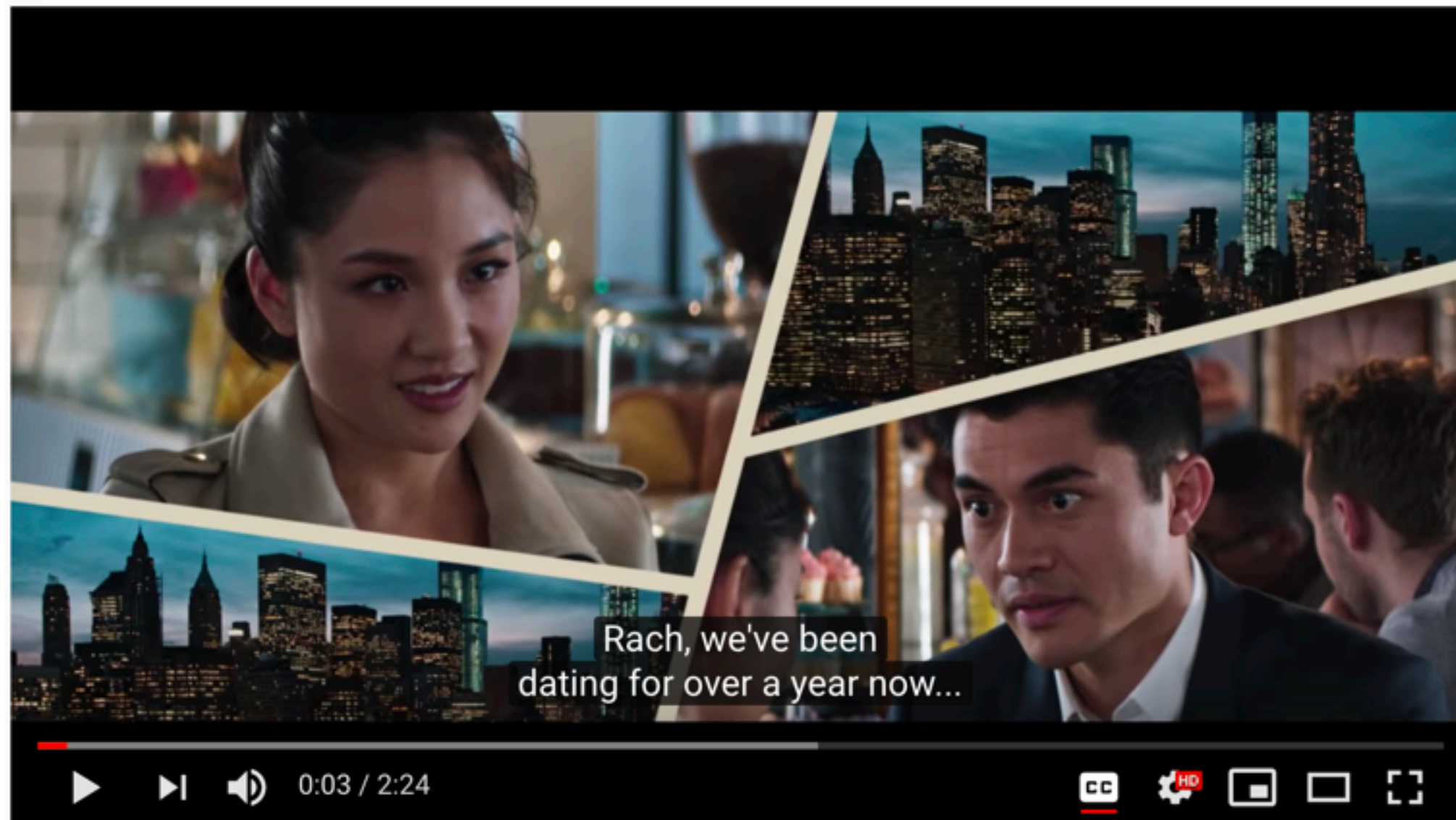
I'd recommend this for someone who needs an echo for their kitchen, bedroom or bathroom. It's just not going to hold down a living room unfortunately but overall, I like the sound and if I need a second echo, I'll definitely get a dot.

234 people found this helpful

Helpful

▼ [Comment](#)

| [Report abuse](#)



[#CrazyRichAsians](#)

CRAZY RICH ASIANS - Official Trailer

23,910,027 views

 170K

 9K

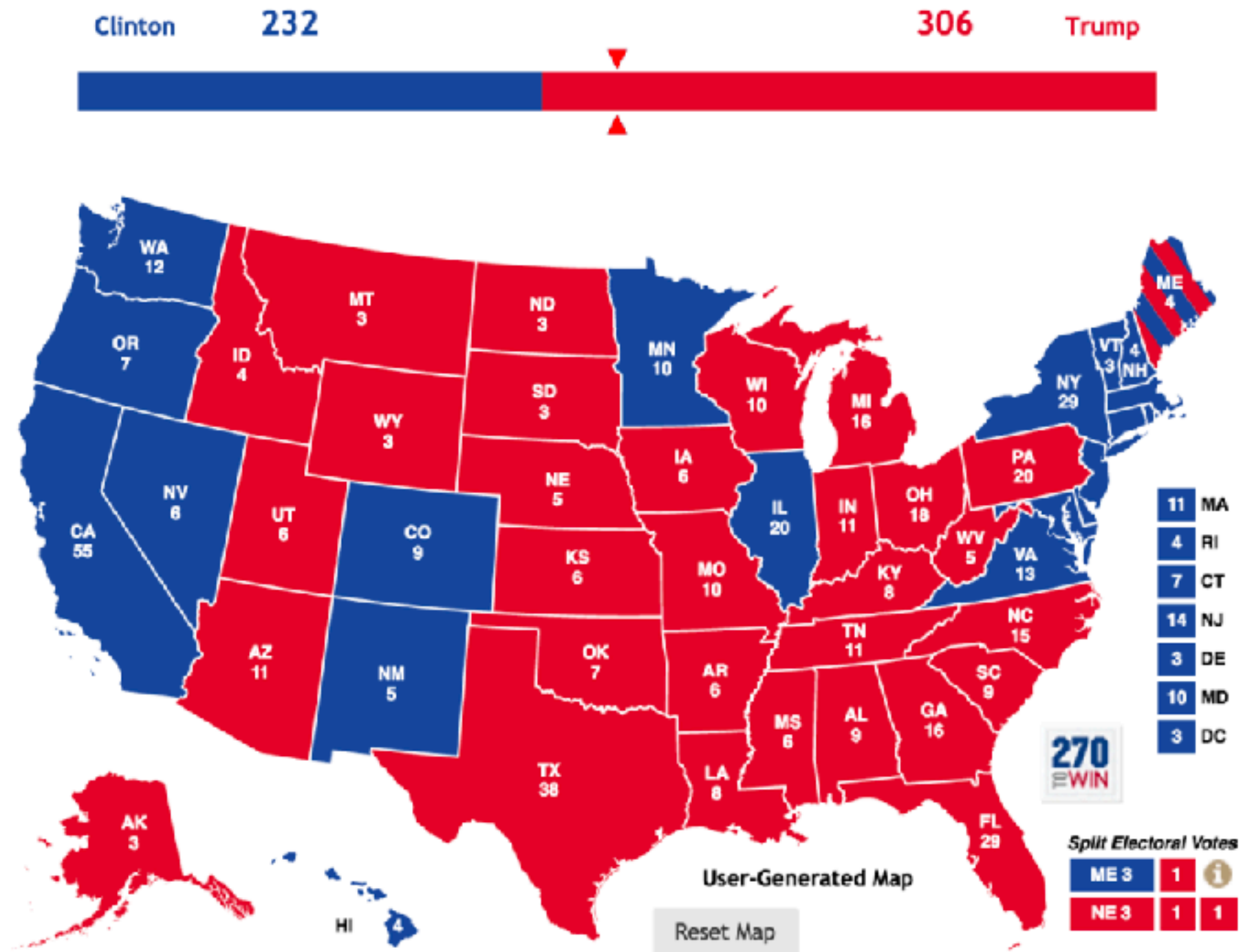
 SHARE

 SAVE

...

Binary Feedback

11



- ▶ Market survey
- ▶ Student response data
- ▶ And more...

- ▶ Ease the process of data acquisition
- ▶ Save the storage



- ▶ Binary feedback *destroys low-rank structure*



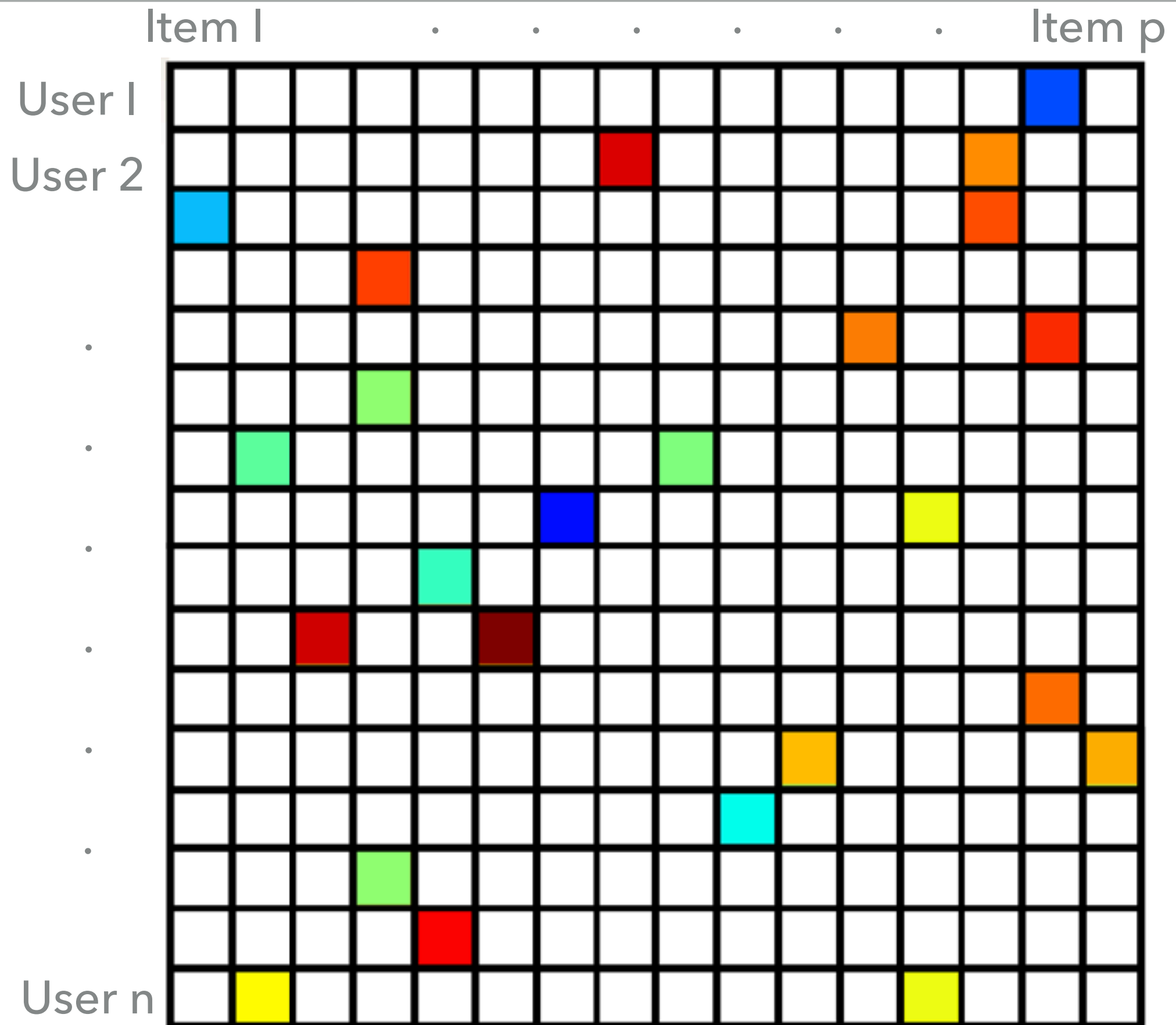
$$\begin{bmatrix} 2 & 4 \\ 1 & 2 \end{bmatrix}$$

Rank 1



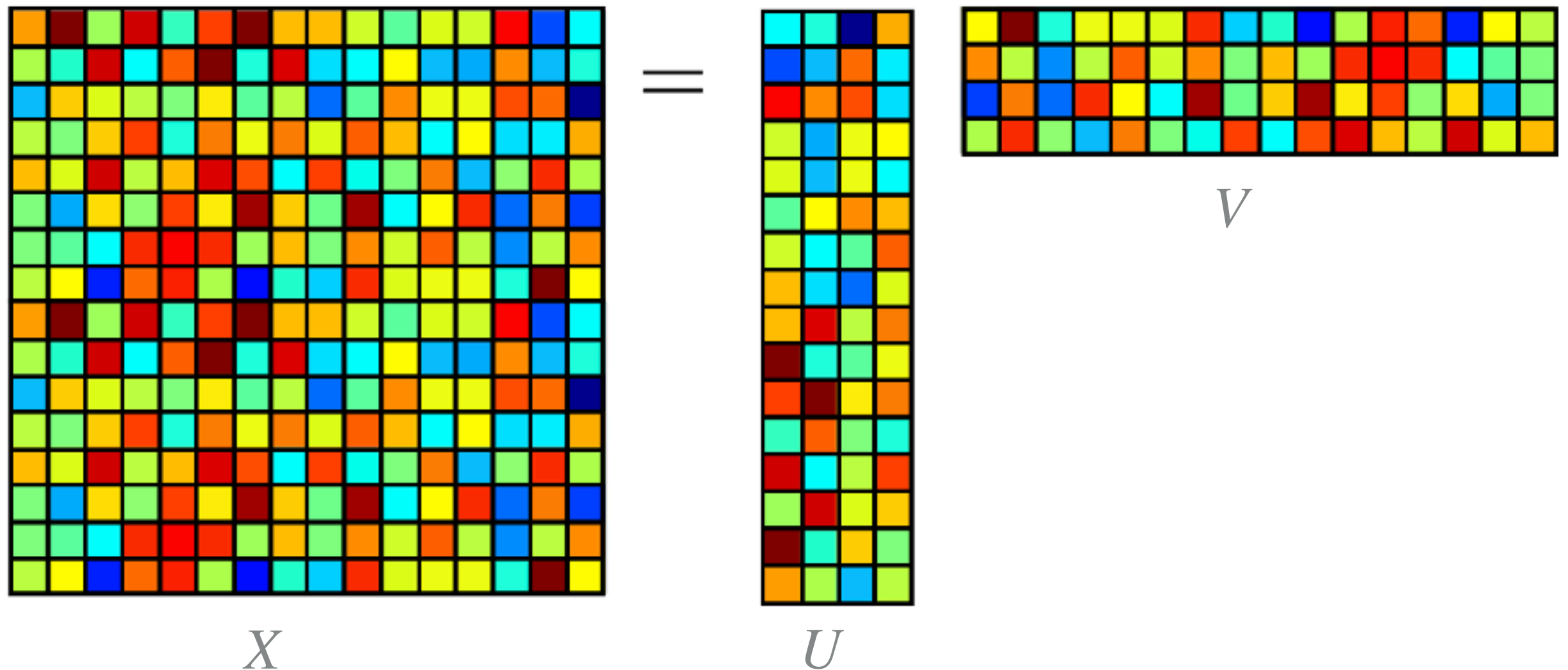
$$\begin{bmatrix} -1 & 1 \\ -1 & -1 \end{bmatrix}$$

Rank 2 - full rank !



- ▶ Traditional collaborative filtering (CF):

$$\min_X \|(Z - X)_{\Omega}\|_F^2, \quad \text{s.t. } \text{rank}(X) \leq r$$



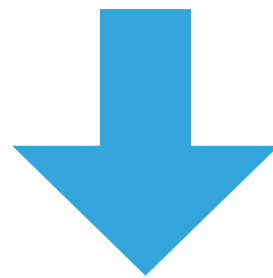
- ▶ CF:
$$\min_{U,V} \|(Z - UV^{\top})_{\Omega}\|_F^2 + \lambda(\|U\|_F^2 + \|V\|_F^2)$$

- ▶ Predict true preference of user based on the binary observation

▶ $\begin{bmatrix} 2 & 4 \\ 1 & 2 \end{bmatrix} \xleftarrow{?} \begin{bmatrix} -1 & 1 \\ -1 & -1 \end{bmatrix}$

- ▶ CF for real-valued data:

$$\min_X \|(Z - X)_{\Omega}\|_F^2, \quad \text{s.t. rank}(X) \leq r$$



- ▶ CF for binary data:

$$\min_X \|(Z - \text{sign}(X))_{\Omega}\|_F^2, \quad \text{s.t. rank}(X) \leq r$$

Z

$$\begin{bmatrix} -1 & 1 \\ -1 & -1 \end{bmatrix}$$

 X

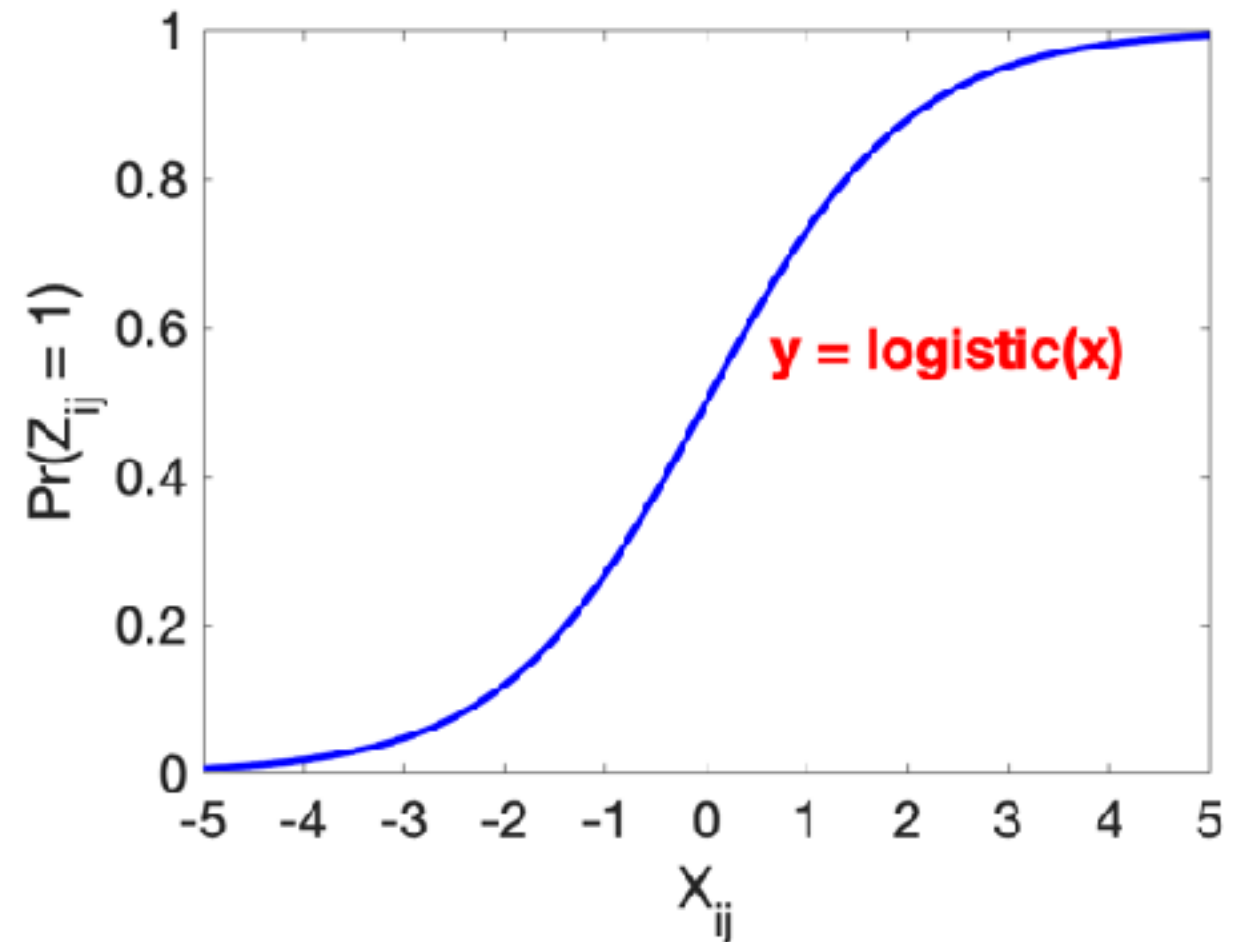
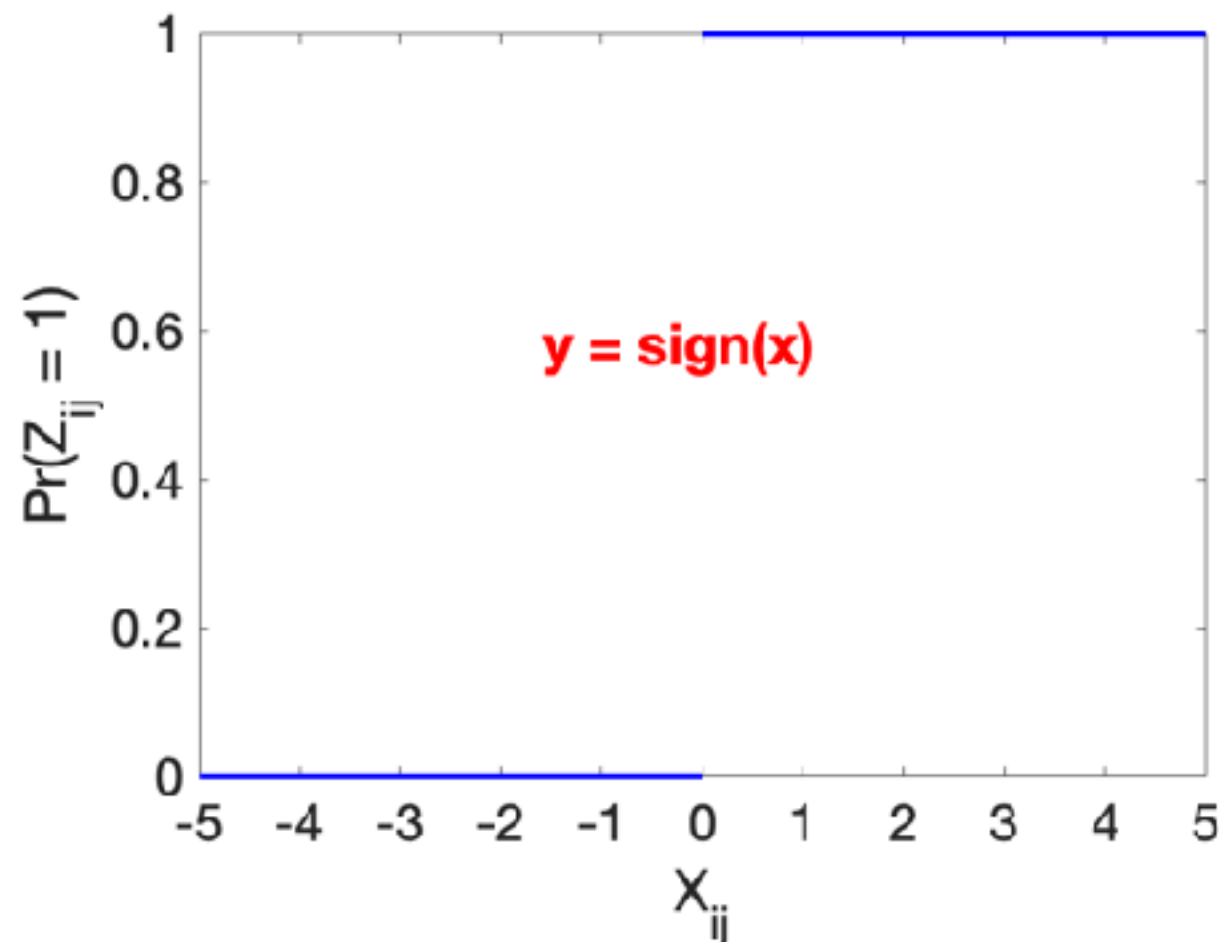
$$\begin{bmatrix} -1 & 3 \\ -2 & -4 \end{bmatrix}$$

 \tilde{X}

$$\begin{bmatrix} -1 & 5 \\ -5 & -1 \end{bmatrix}$$

- ▶ Sign function absorbs magnitude

- ▶ For $(i, j) \in \Omega$ $Z_{i,j} = \begin{cases} +1, & \text{with probability } f(X_{i,j}) , \\ -1, & \text{with probability } 1 - f(X_{i,j}) . \end{cases}$
- ▶ $f(X_{i,j}) = \frac{1}{1 + e^{-X_{i,j}}}$ is logistic function



- ▶ Negative log-likelihood function:

$$\begin{aligned} L(X; Z, \Omega) &= - \sum_{(i,j) \in \Omega} \left(\mathbf{1}_{[Z_{i,j}=1]} \log(f(X_{i,j})) + \mathbf{1}_{[Z_{i,j}=-1]} \log(1 - f(X_{i,j})) \right) \\ &= \sum_{(i,j) \in \Omega} \left(\log(1 + \exp(-Z_{i,j}X_{i,j})) \right) \end{aligned}$$

- ▶ Maximum Likelihood Estimation:

$$\min L(X; Z, \Omega), \quad \text{s.t.} \quad \text{rank}(X) \leq r$$

- ▶ The gradients with respect to u_i and v_j are given by

$$\nabla_u L(U, V; Z, \Omega) = \frac{-Z_{i,j}}{1 + \exp(Z_{i,j}u_i v_j^\top)} v_j,$$

$$\nabla_v L(U, V; Z, \Omega) = \frac{-Z_{i,j}}{1 + \exp(Z_{i,j}u_i v_j^\top)} u_i.$$

- ▶ For iteration $t = 1, \dots, T$
 - ▶ Randomly choose an entry $Z_{i,j}$ with $(i, j) \in \Omega$
 - ▶ Update the new iterate

$$u_i \longleftarrow \Pi(u_i - \alpha_t \nabla_u)$$

$$v_j \longleftarrow \Pi(v_j - \alpha_t \nabla_v)$$