

# Recommendation Systems



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# Happy Festival Season!!!



# Recommendations - Overview



Flipkart

Signup | Login

So, what are you wishing for today?

SEARCH

CART

ELECTRONICS MEN WOMEN BABY & KIDS HOME & FURNITURE BOOKS & MEDIA



## Puma Striped Men's Polo T-Shirt

★★★★★ 1

Write a REVIEW Add to WISHLIST

Select Color



Select Size

S M

SIZE CHART

Available with 1 Seller at 560035 [Change](#)

Rs. 1,499

List Price

(Free delivery)

ADD TO CART

BUY NOW

Unlock mega savings with Great Offers

OPEN IN APP

- Easy Returns
- Brand New
- 100% Original
- Pay Securely

SOLD BY

WS Retail 4.2 / 5 [Advantage](#)

DELIVERED BY ?

Mon, 19th Oct: FREE

CASH ON DELIVERY

? Available

30 day Exchange Guarantee. ?

### CUSTOMERS WHO VIEWED THIS PRODUCT ALSO VIEWED



Puma Striped Men's Polo T-Shirt

★★★★★

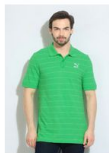
Rs 1,499



Puma Striped Men's Polo T-Shirt

★★★★★

Rs 1,499 (50% Off)  
Rs 748



Puma Striped Men's Polo T-Shirt

★★★★★

Rs 1,299



Puma Striped Men's Polo T-Shirt

★★★★★

Rs 1,799



Puma Striped Men's Polo T-Shirt

★★★★★

Rs 1,799 (40% Off)  
Rs 1,079

Flipkart

So, what are you wishing for today?

SEARCH

CART

ELECTRONICS MEN WOMEN BABY & KIDS HOME & FURNITURE BOOKS & MEDIA AUTO & SPORTS OFFER

Home > Mobiles & Accessories > Mobiles > Motorola Mobiles > Moto G (3rd Generation) (Black, 16 GB)



## Moto G (3rd Generation) (Black, 16 GB)

★★★★★ 8314 2,273 REVIEWS

Write a REVIEW Add to WISHLIST Add to COMPARE

- IPX7 Water Resistance
- 13 MP Primary Camera
- 2470 mAh Battery
- 4G LTE

WARRANTY

1 year manufacturer warranty for Phone and for in the box accessories

Color



Storage

16 GB 8 GB

View Compatible Accessories.

Available with 1 Seller at 560035 [Change](#)

Rs. 12,999

List Price

EMI starts from Rs. 631 ?  
(Free delivery)

ADD TO CART

BUY NOW

SOLD BY

WS Retail 4.2 / 5 [Advantage](#)

DELIVERED BY ?

Sat, 17th Oct: FREE

CASH ON DELIVERY

? Available

30 day Replacement Guarantee. ?

### COMPLETE THE PURCHASE

ALL CATEGORIES (35)

MOBILE CASES & COVERS (3)

MOBILE SCREEN GUARDS (7)



Motorola Flip Cover for Moto G (3rd Gen) (Blue)

★★★★★

Rs 1,799



Motorola Flip Cover for Moto G (3rd Gen)

★★★★★

Rs 1,799



Motorola Back Replacement Cover for

★★★★★

Rs 999



Scratchgard Original Anti Glare - (MotoG)

★★★★★

Rs 379 (53% Off)  
Rs 175



Shop Buzz Temp-MotoG3 Tempered

★★★★★

Rs 399 (68% Off)  
Rs 125



Karpine Scr10757/Clear Screen Guard for

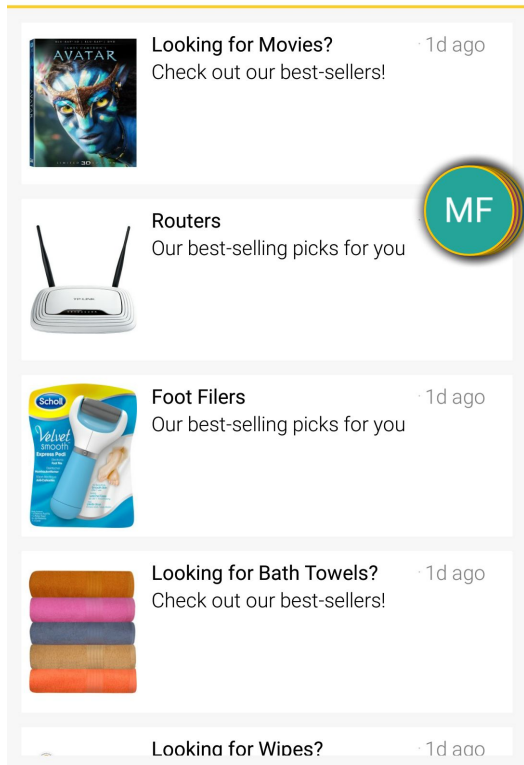
★★★★★

Rs 649 (72% Off)  
Rs 149

# Recommendation Overview



## Notifications



- Related product recommendation (Flipkart)
- Movie recommendation (Netflix)
- Web page ranking (Google)
- Social recommendation (Facebook)
- News content recommendation (Yahoo)
- Priority inbox & spam filtering (Google)
- Online dating (OK Cupid)
- Computational Advertising (Yahoo)
- Event recommendation



- Type of Methods
  - Collaborative filtering
  - Content based
  - Hybrid
- Collaborative Filtering
  - Neighbourhood methods
  - Matrix factorization




- Slides are prepared by leveraging internet heavily
  - <http://www2.research.att.com/~volinsky/papers/ieeecomputer.pdf>
  - <http://www.slideshare.net/xamat>
  - [http://alex.smola.org/teaching/berkeley2012/slides/8\\_Recommender.pdf](http://alex.smola.org/teaching/berkeley2012/slides/8_Recommender.pdf)
  - <http://blog.comsysto.com/2013/04/03/background-of-collaborative-filtering-with-mahout/>
  - [Simon funk's blog](#)



- User activity

- Movies
  - Ratings, reviews, movies rented, watched
- E-commerce
  - Browse, wishlist, share, ratings, etc.



Collaborative  
filtering

- Item details

- Movies
  - Actors, Directors, Genre, etc.
- E-commerce
  - Product attributes, images, description



Content  
Based



Hybrid

# CF - Neighbourhood Methods





## CUSTOMERS WHO VIEWED THIS PRODUCT ALSO VIEWED



GAS Printed Men's Round Neck T-Shirt



GAS Printed Men's Round Neck T-Shirt



GAS Printed Men's Round Neck T-Shirt



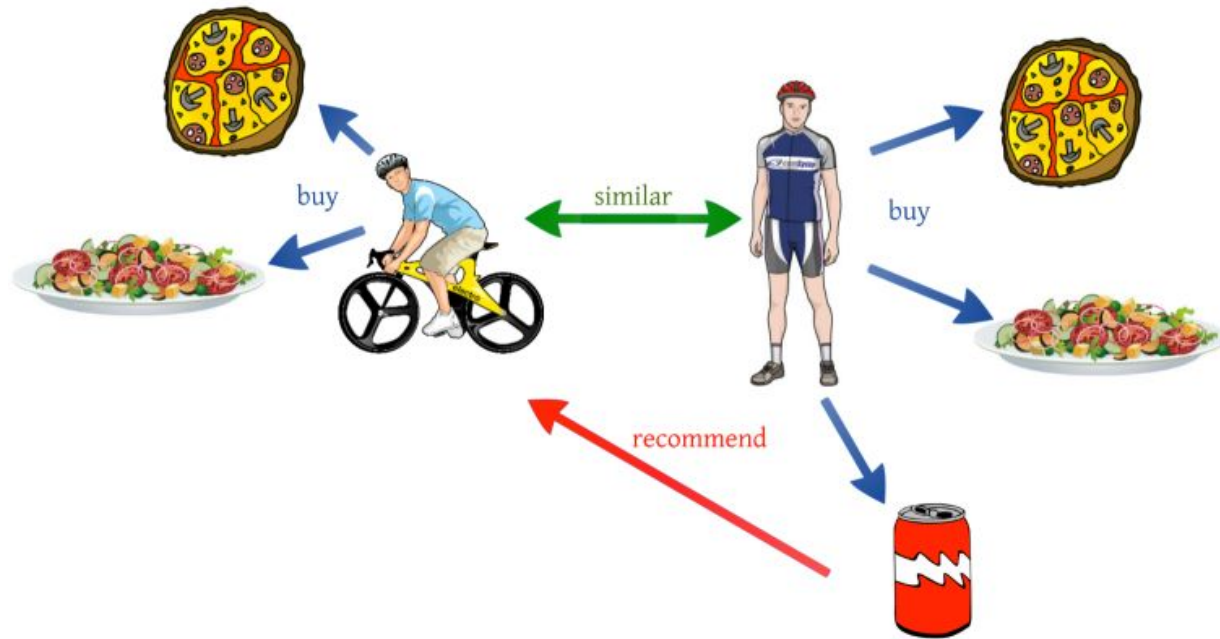
GAS Printed Men's Round Neck T-Shirt



Gas Printed Men's Round Neck T-Shirt



# Neighbourhood Method



# Neighbourhood Method - Setup



		Users					
Items		3		2	1		
		4	4	?	5	3	
		1	2	2		4	
		2		2		4	



- $r_{ui} = ?$
- For user  $u$ , find similar users ( $u'$ )
- Find likeness of item  $i$  for similar users.

$$r_{u,i} = \frac{1}{N} \sum_{u' \in U} r_{u',i}$$

$$r_{u,i} = k \sum_{u' \in U} \text{simil}(u, u') r_{u',i} \quad k = 1 / \sum_{u' \in U} |\text{simil}(u, u')|$$

$$r_{u,i} = \bar{r}_u + k \sum_{u' \in U} \text{simil}(u, u') (r_{u',i} - \bar{r}_{u'})$$



- Pearson correlation

$$\text{simil}(x, y) = \frac{\sum_{i \in I_{xy}} (r_{x,i} - \bar{r}_x)(r_{y,i} - \bar{r}_y)}{\sqrt{\sum_{i \in I_{xy}} (r_{x,i} - \bar{r}_x)^2 \sum_{i \in I_{xy}} (r_{y,i} - \bar{r}_y)^2}}$$



- Similar to (user, user) similarity
- Find users who have liked a product
- Find other products liked by these users



- Pros:
  - Intuitive and easy to explain to user
  - Easy to setup
  - Produces good-enough results
- Cons:
  - Scalability
  - Sparseness -> coverage -> cold start

# Matrix factorization



4	?	?	?
?	?	?	5
?	1	?	2
3	?	?	?
?	2	?	?

$5 * 4$

$=$

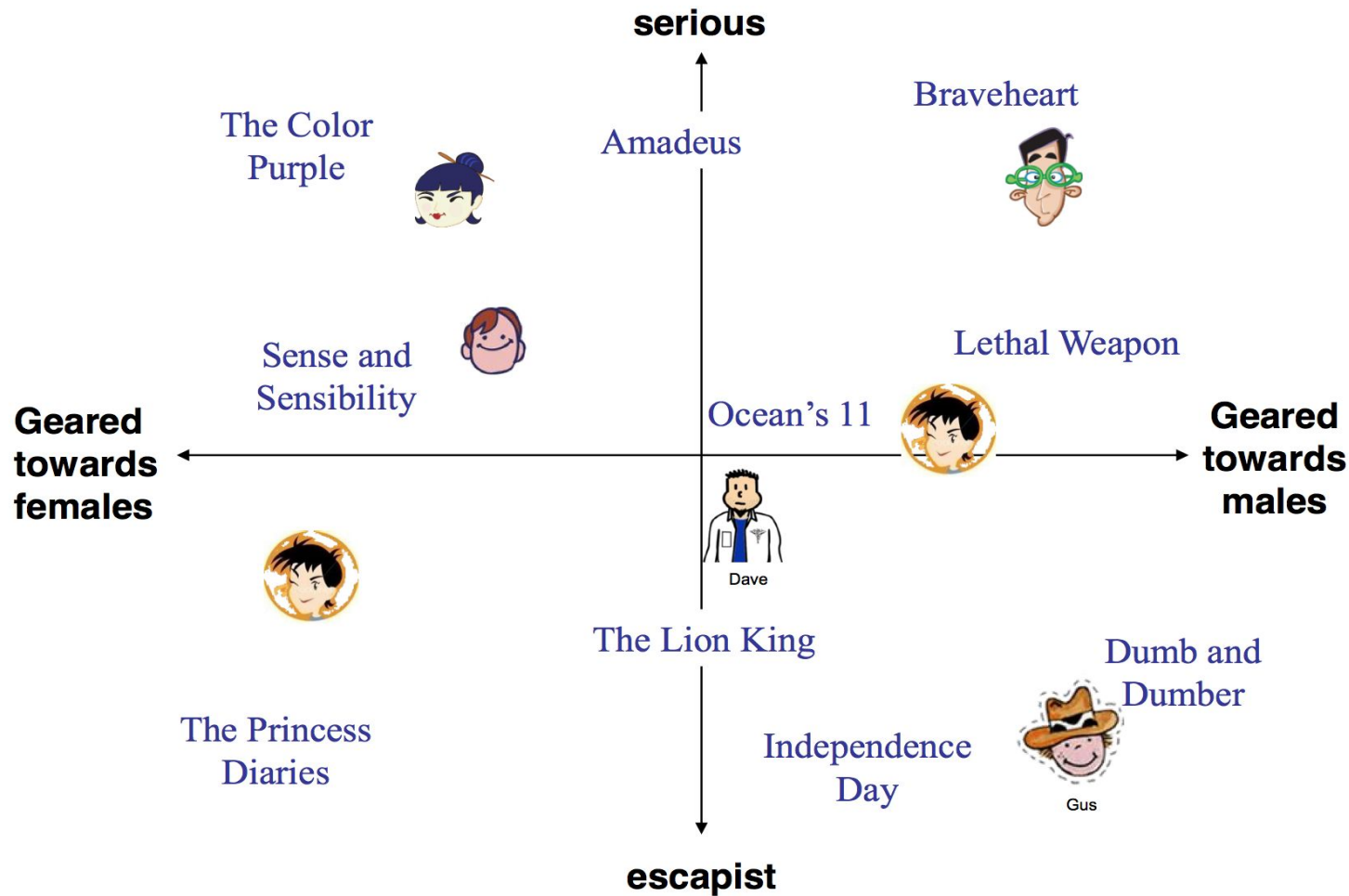

$5 * 2$

$\times$


$2 * 4$

$$\hat{r}_{ui} = q_i^T p_u.$$







- Similar to SVD, but missing values!!
- Overfitting is one major problem
- SGD for learning latent factors
- Objective function:

$$\min_{q^*, p^*} \sum_{(u,i) \in \mathcal{K}} (r_{ui} - q_i^T p_u)^2 + \lambda (\|q_i\|^2 + \|p_u\|^2)$$

Regularization Constant



- Compute error

$$e_{ui} \stackrel{\text{def}}{=} r_{ui} - q_i^T p_u.$$

- Adjust the factors

$$\begin{aligned} q_i &\leftarrow q_i + \gamma \cdot (e_{ui} \cdot p_u - \lambda \cdot q_i) \\ p_u &\leftarrow p_u + \gamma \cdot (e_{ui} \cdot q_i - \lambda \cdot p_u) \end{aligned}$$

Learning rate

A blue arrow pointing from the text 'Learning rate' to the gamma symbol in the equations above.

# Adding Biases



$$b_{ui} = \mu + b_i + b_u$$

Diagram illustrating the components of the bias term  $b_{ui}$ :

- $\mu$  is labeled as Global Bias.
- $b_i$  is labeled as Item Bias.
- $b_u$  is labeled as User Bias.

$$\hat{r}_{ui} = \mu + b_i + b_u + q_i^T p_u$$

$$\min_{p^*, q^*, b^*} \sum_{(u,i) \in K} (r_{ui} - \mu - b_u - b_i - p_u^T q_i)^2 + \lambda (\|p_u\|^2 + \|q_i\|^2 + b_u^2 + b_i^2)$$

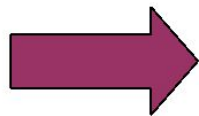
# Implicit feedback



users

movies

1		3			5			5		4	
		5	4			4			2	1	3
2	4		1	2		3		4	3	5	
	2	4		5			4			2	
		4	3	4	2					2	5
1		3		3			2			4	



users

movies

1	0	1	0	0	1	0	0	1	0	1	0
0	0	1	1	0	0	1	0	0	1	1	1
1	1	0	1	1	0	1	0	1	1	1	0
0	1	1	0	1	0	0	1	0	0	1	0
0	0	1	1	1	1	0	0	0	0	1	1
1	0	1	0	1	0	0	1	0	0	1	0



- Objective function with implicit feedback formulation

$$\min_{p^*, q^*, b^*} \sum_{(u,i) \in K} c_{ui} (r_{ui} - \mu - b_u - b_i - p_u^T q_i)^2 + \lambda (\|p_u\|^2 + \|q_i\|^2 + b_u^2 + b_i^2)$$



Thank You