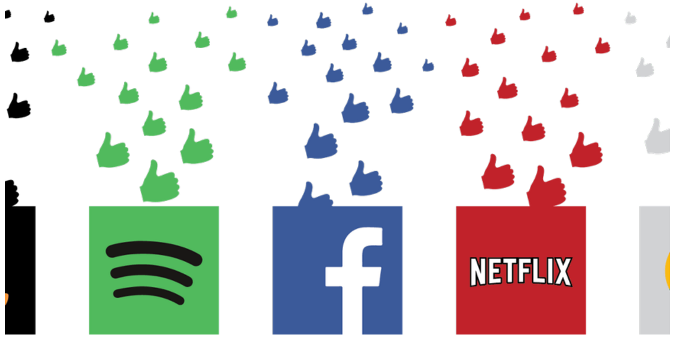
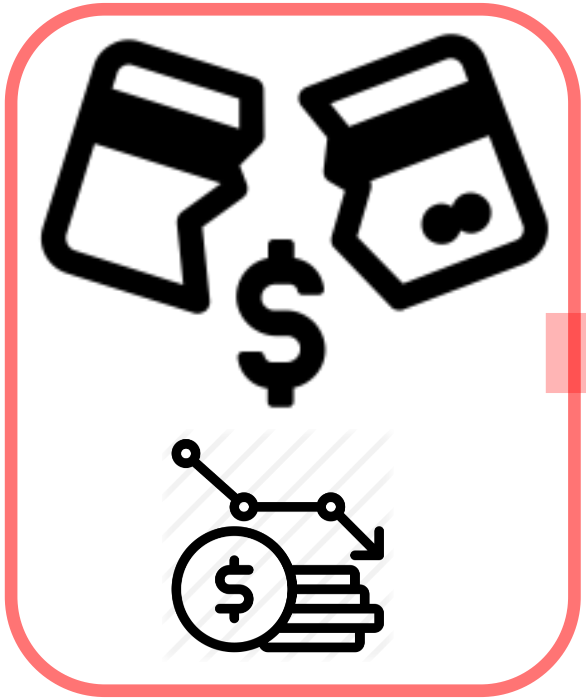


Recommender System on Amazon Game data

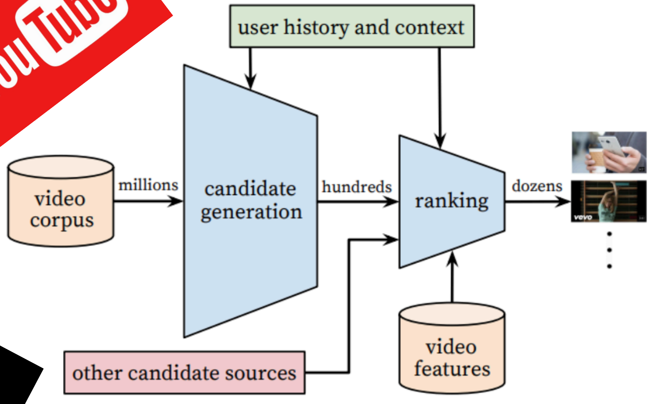
Jae Choi

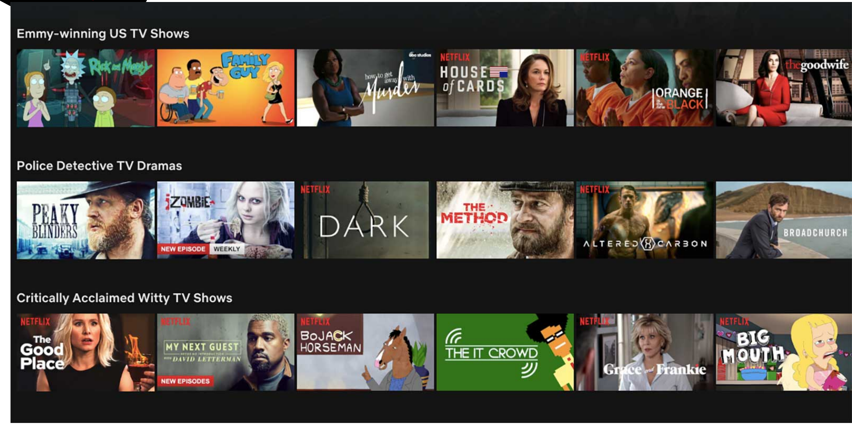
Contact Info: Jaehyuk0325@gmail.com

PROBLEMS



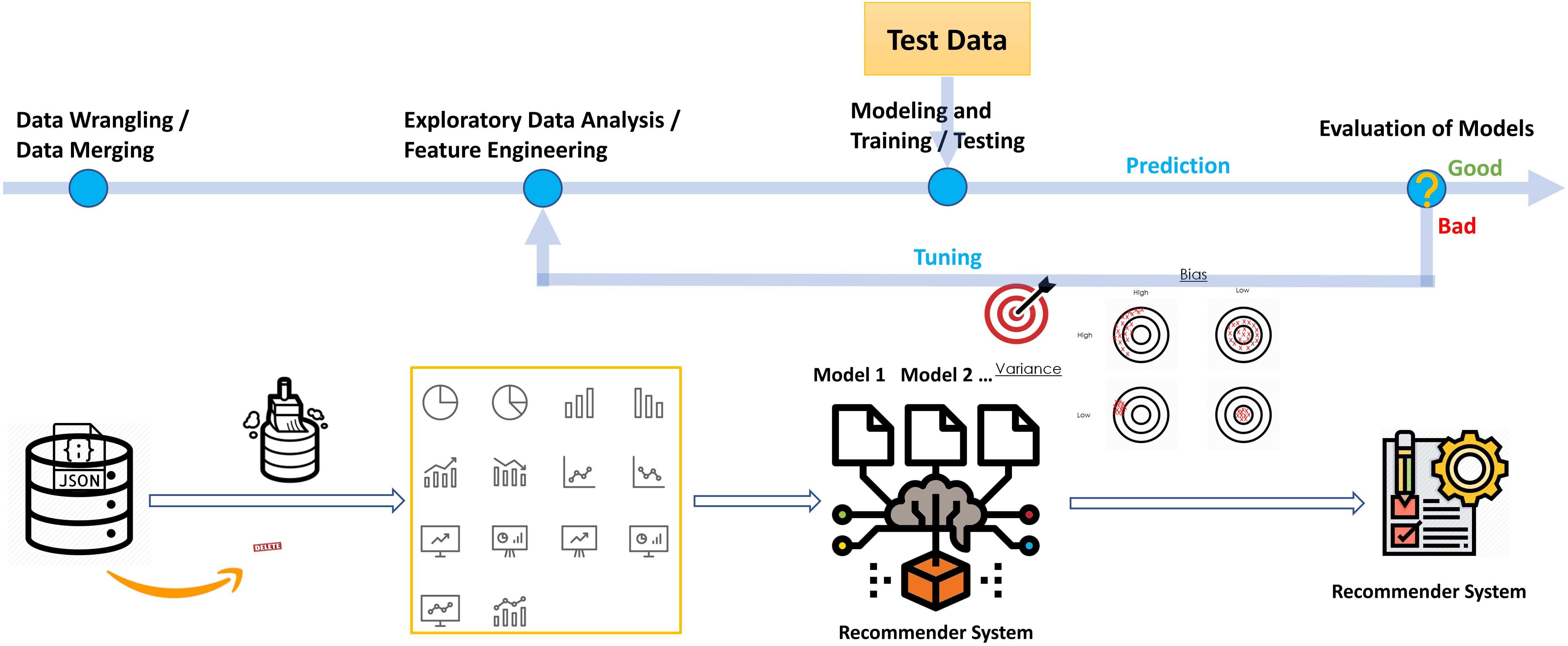

recommend
social
follow
media
friend
like
reputation
online
seo
network
blog
rank
wall
share
group
Walmart
Save money. Live better.


user history and context
video corpus
millions
candidate generation
hundreds
ranking
dozens
video features
other candidate sources


Emmy-winning US TV Shows
Police Detective TV Dramas
Critically Acclaimed Witty TV Shows


amazon.com
Help | Close window
Recommended for You
Inside Apple: How America's Most Admired--and Secretive--Company Really Works
Our Price: $9.99
Used & new from $9.99
See all buying options
Rate this item
I own it
Not interested
Because you purchased...
The Toyota Way : 14 Management Principles from the World's Greatest Manufacturer
(Kindle Edition)
This was a gift
Don't use for recommendations

STEPS



Data
Total Rows: ~2.56 million
# of Users: ~72K,
# of Items: ~1.54 million

Cleaned Data:
Total Rows: ~50k
# of Users: **~**23k,
# of Items: 241

Data Split
Trainset: **~34.7k**
Testset: **~14.8K**

DATA WRANGLING

JSON
Metadata

CSV
Ratings

Merged Data:
Total Rows: ~2.56 million
# of Users: ~72,000,
# of Items: ~1.54 million

Data Extraction:

- 5 years valid data (2014 – 2018)
- Filtering out the reviews of non-purchasers

pandas

Data Imputation
Data Type Conversion

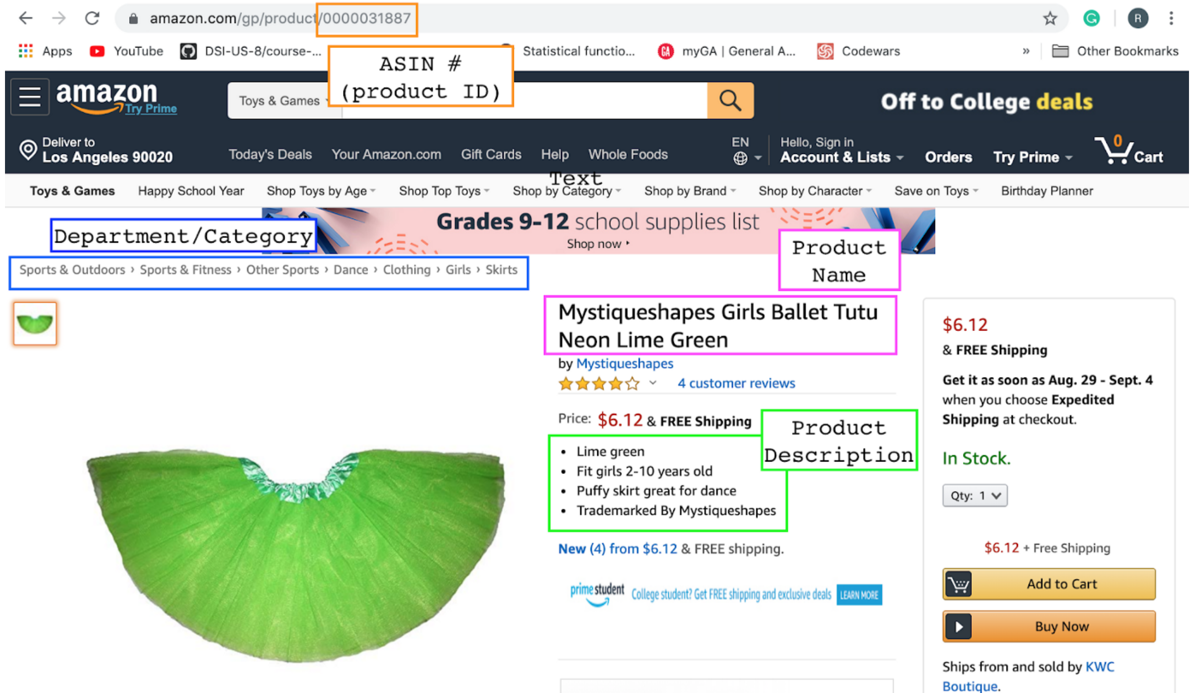
Cleaned Data:
Total Rows: ~49,535
# of Users: ~23,789,
# of Items: 241

User-Item Matrix

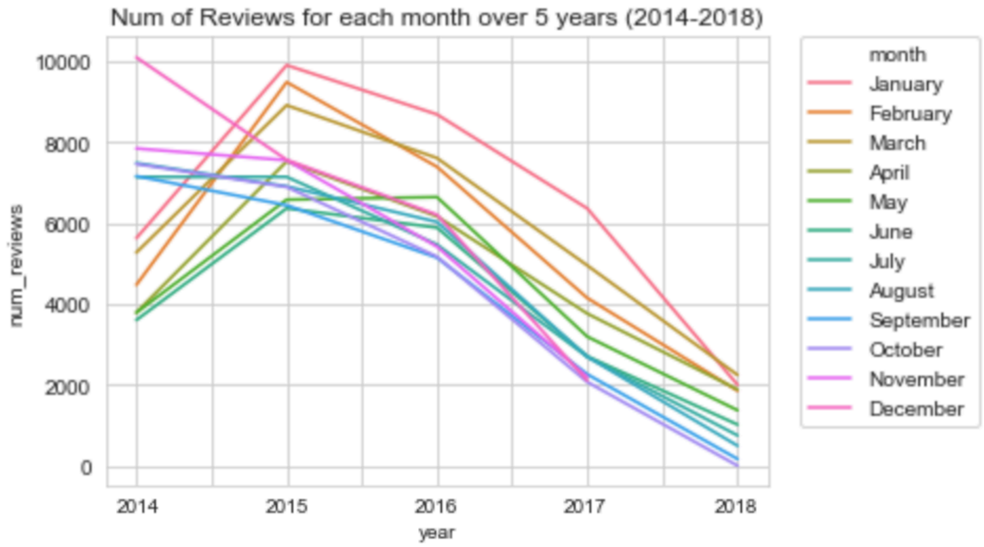
	Item1	Item2	Item3	Item4	Item5
Alice	5	3	4	4	?
User1	3	1	2	3	3
User2	4	3	4	3	5
User3	3	3	1	5	4
User4	1	5	5	2	1

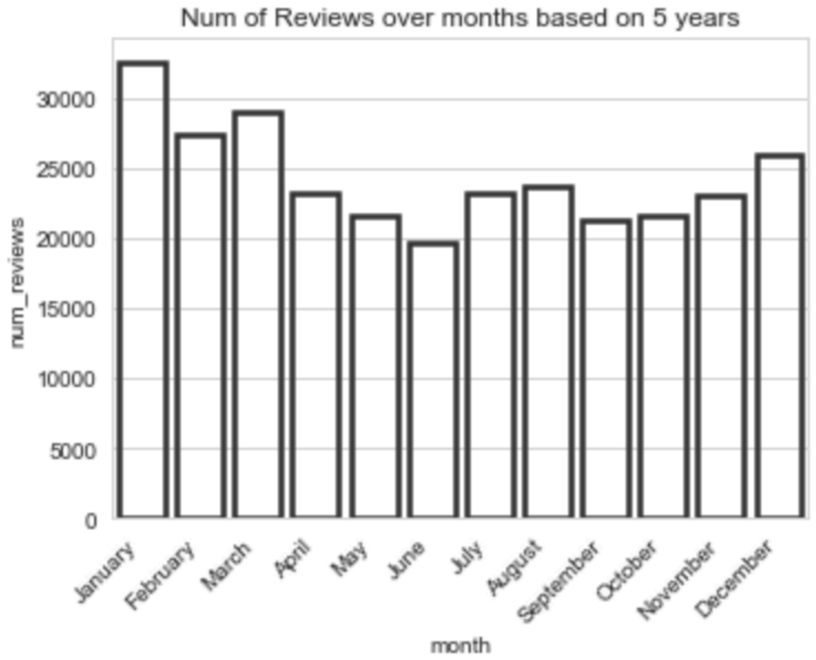
Sample Review:

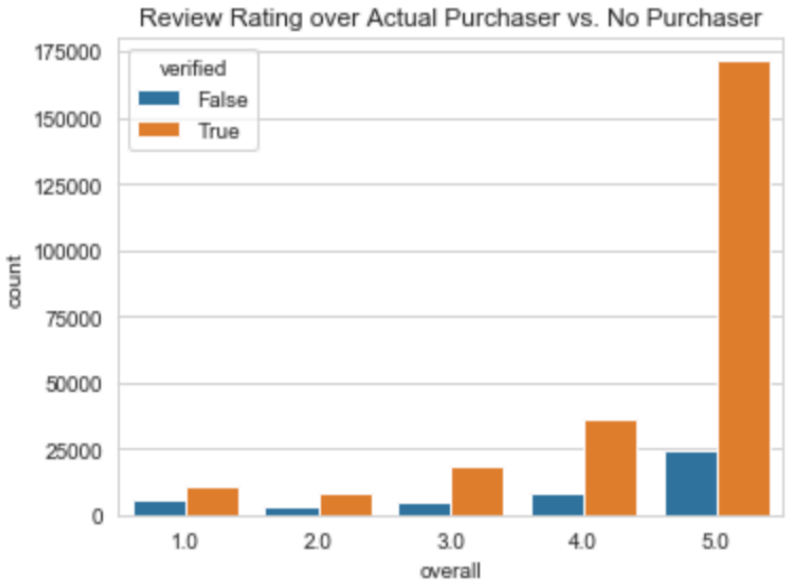
{
"reviewerID": "A2SUAM1J3GNN3B",
"asin": "0000013714",
"reviewerName": "J. McDonald",
"vote": 5,
"style": {"Format:": "Hardcover"},
"reviewText": "I bought this for my husband who plays the piano. He is having a wonderful time playing these old hymns. The music is at times hard to read because we think the book was published for singing from more than playing from. Great purchase though!",
"overall": 5.0,
"summary": "Heavenly Highway Hymns",
"unixReviewTime": 1252800000,
"reviewTime": "09 13, 2009"
}



EDA







Yearly Reviews (2014 – 2018)

- Rising trend 2014 – 2015
- Falling trend 2015 – 2018
- # of reviews over WINTER season tends >> that over SUMMER season.

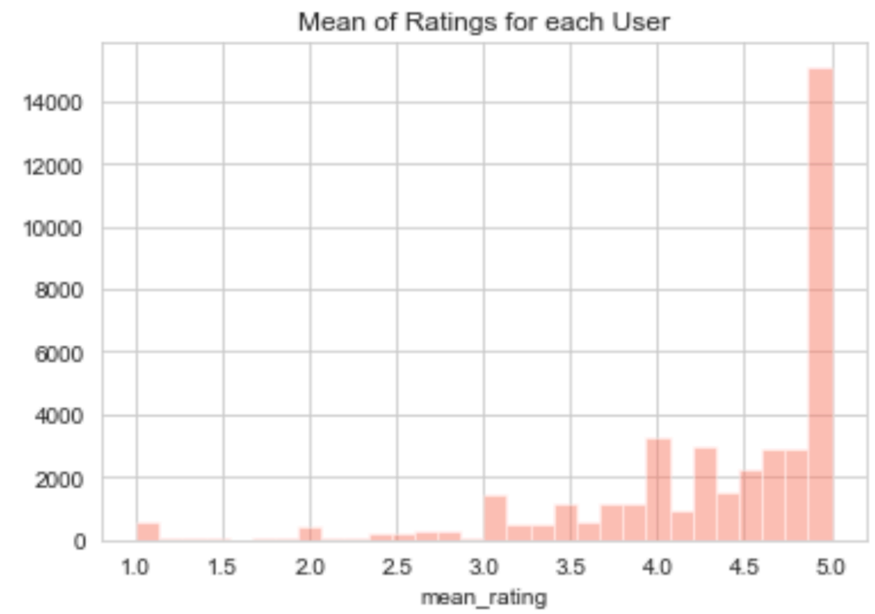
Monthly Reviews (2014 – 2018)

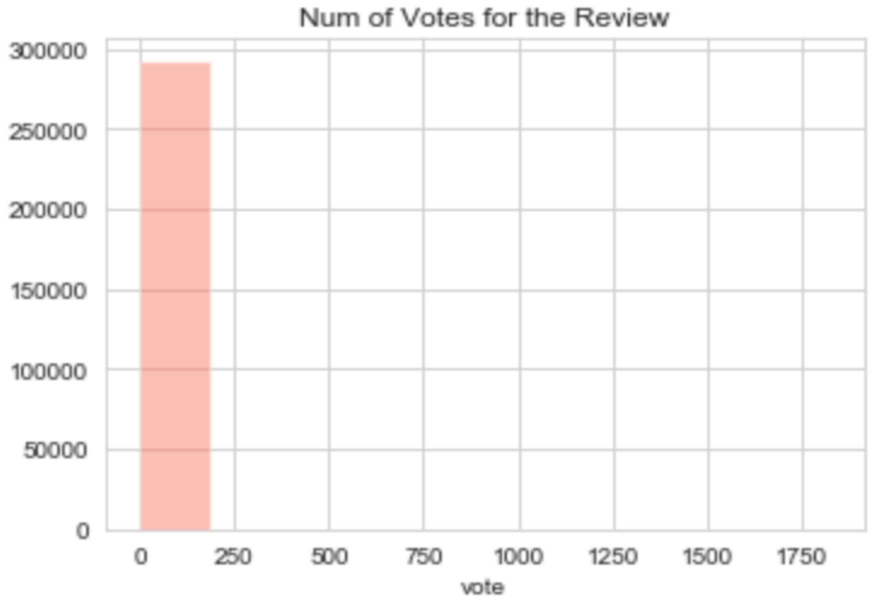
- Increment over SUMMER break.
- Falling trend Jan – June

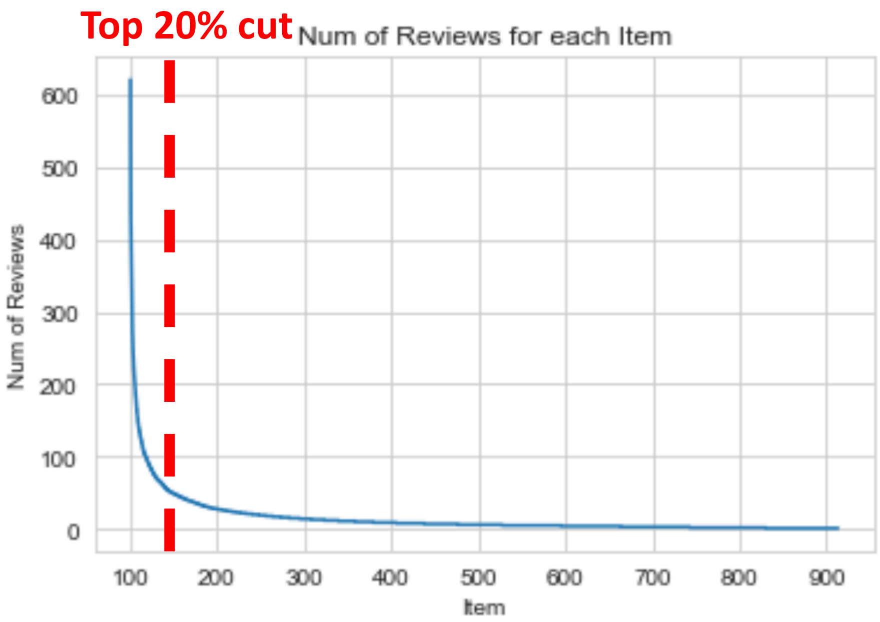
Real Buyer vs. No Buyer

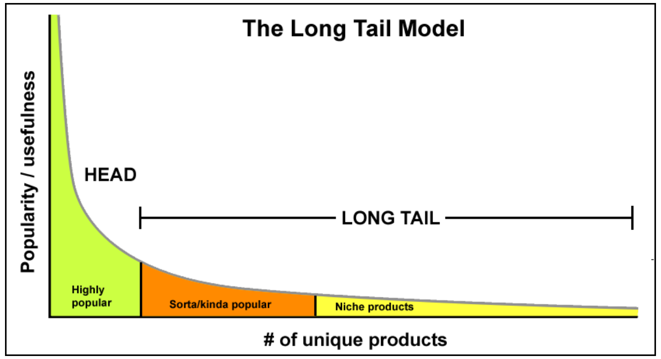
- Both are LEFT skewed
- Data of real buyers is skewed more dramatically.

EDA









Mean of Reviews (2014 – 2018)

- Trend over only real buyers.

# of Reviews for Each Item

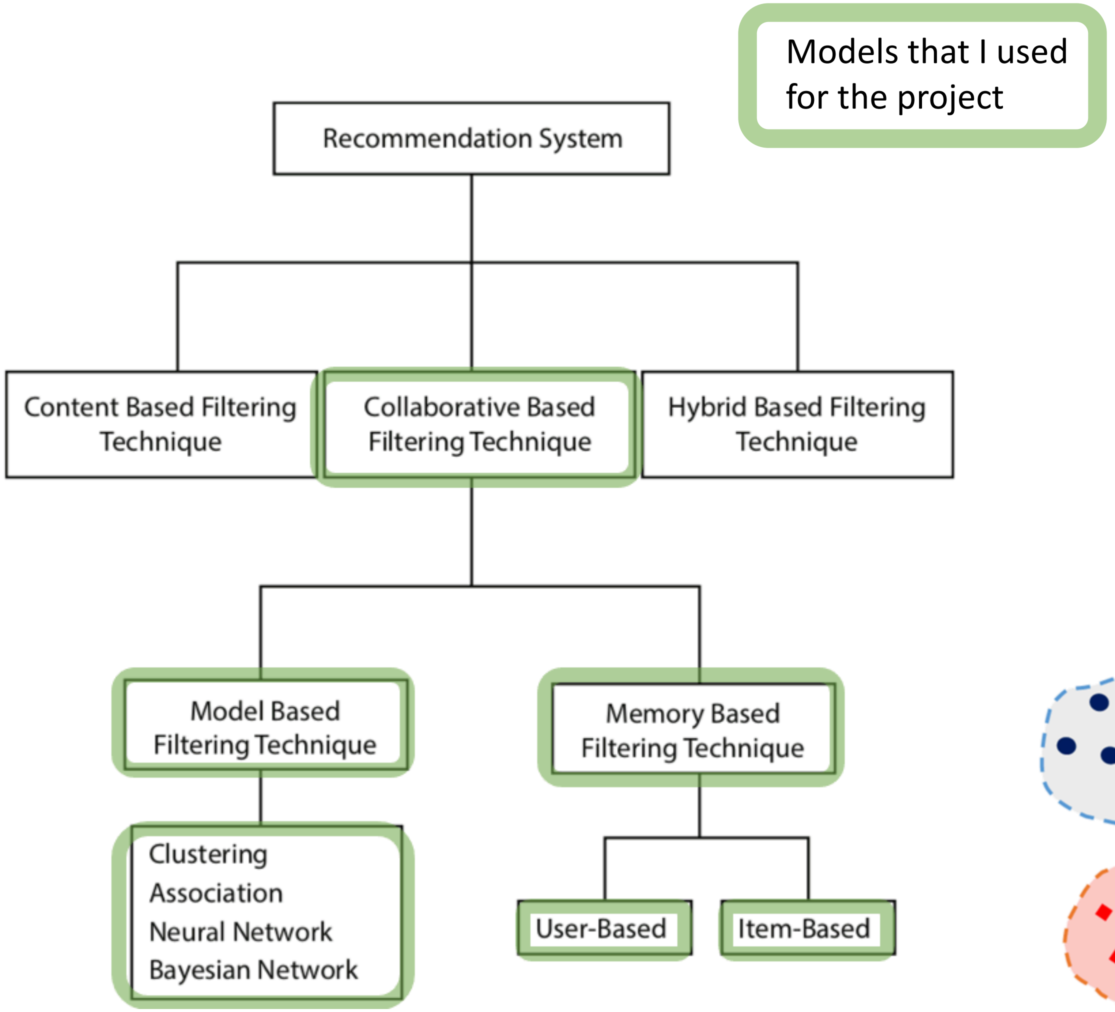
- Popularity cut top 20 %

# of Votes for Reviews

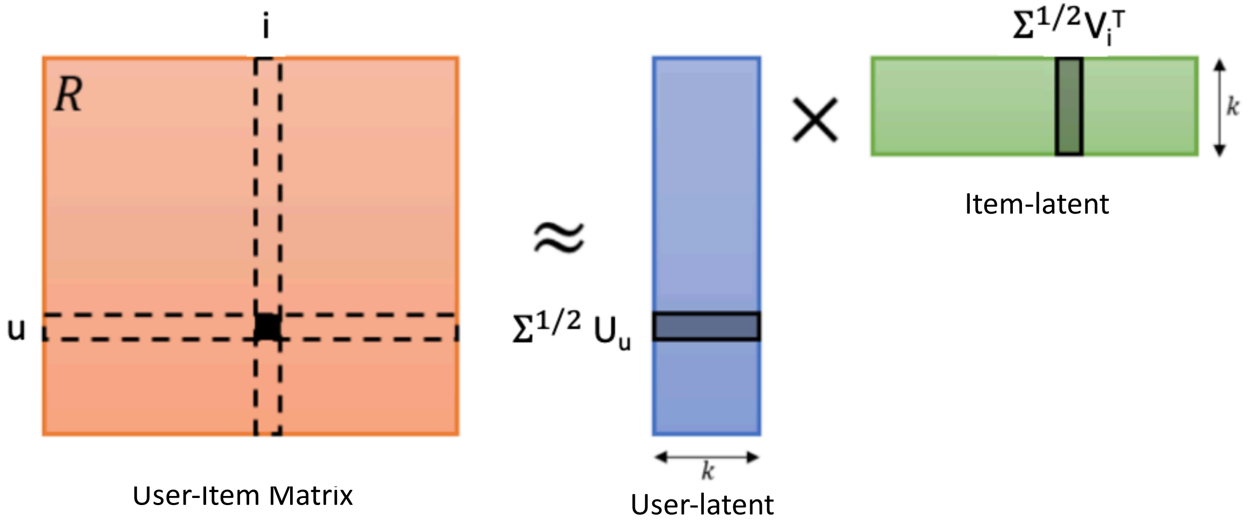
- Range of # of votes (Mostly < 250).
- Some OUTLIERs over 1500 votes

MODELING

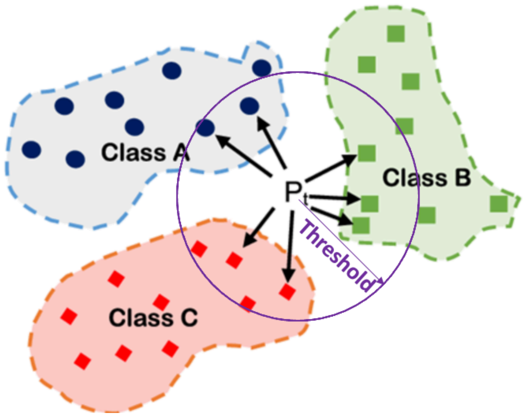
Recommender System Types



Model-based:
Matrix Factorization



Memory-based:
KNN



	Item1	Item2	Item3	Item4	Item5
Alice	5	3	4	4	?
User1	3	1	2	3	3
User2	4	3	4	3	5
User3	3	3	1	5	4
User4	1	5	5	2	1

Similarity

	Item1	Item2	Item3	Item4	Item5
Alice	5	3	4	4	?
User1	3	1	2	3	3
User2	4	3	4	3	5
User3	3	3	1	5	4
User4	1	5	5	2	1

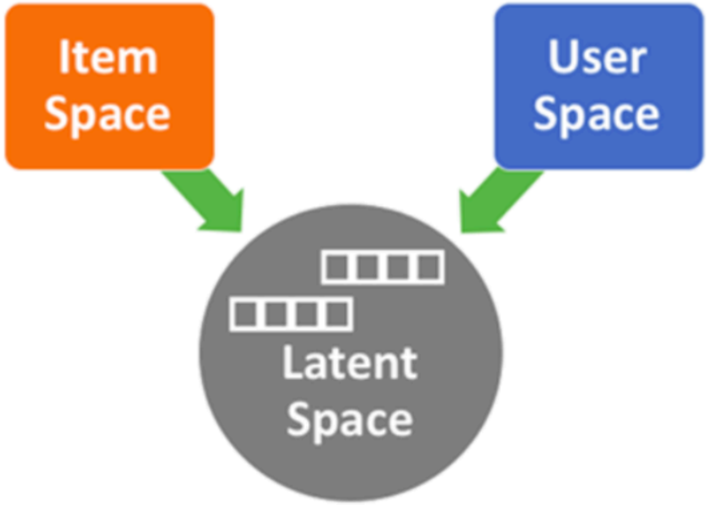
Similarity

MODELING

Content-based Filtering

Hybrid Filtering

Model-based CF



Latent Model

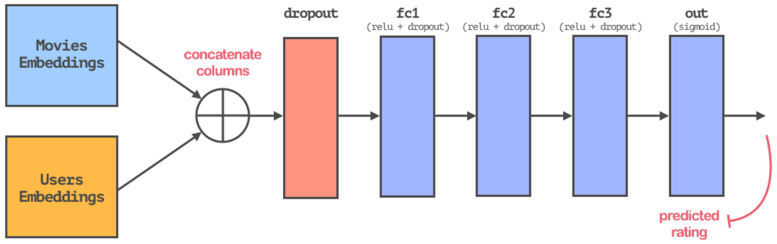
- SVD
- SVD++
- NMF

Memory-based CF

Neighborhood Model

- KNN
- KNN with Means
- KNN with Z-score

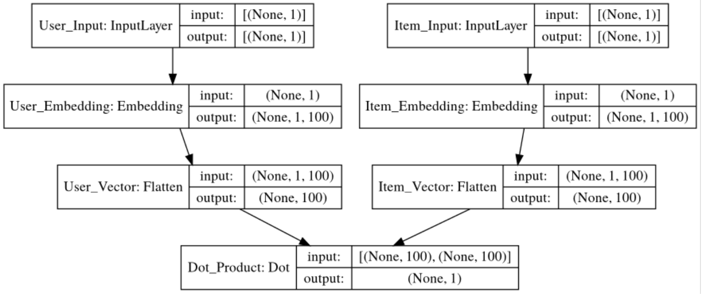
Deep Learning based Recommender System



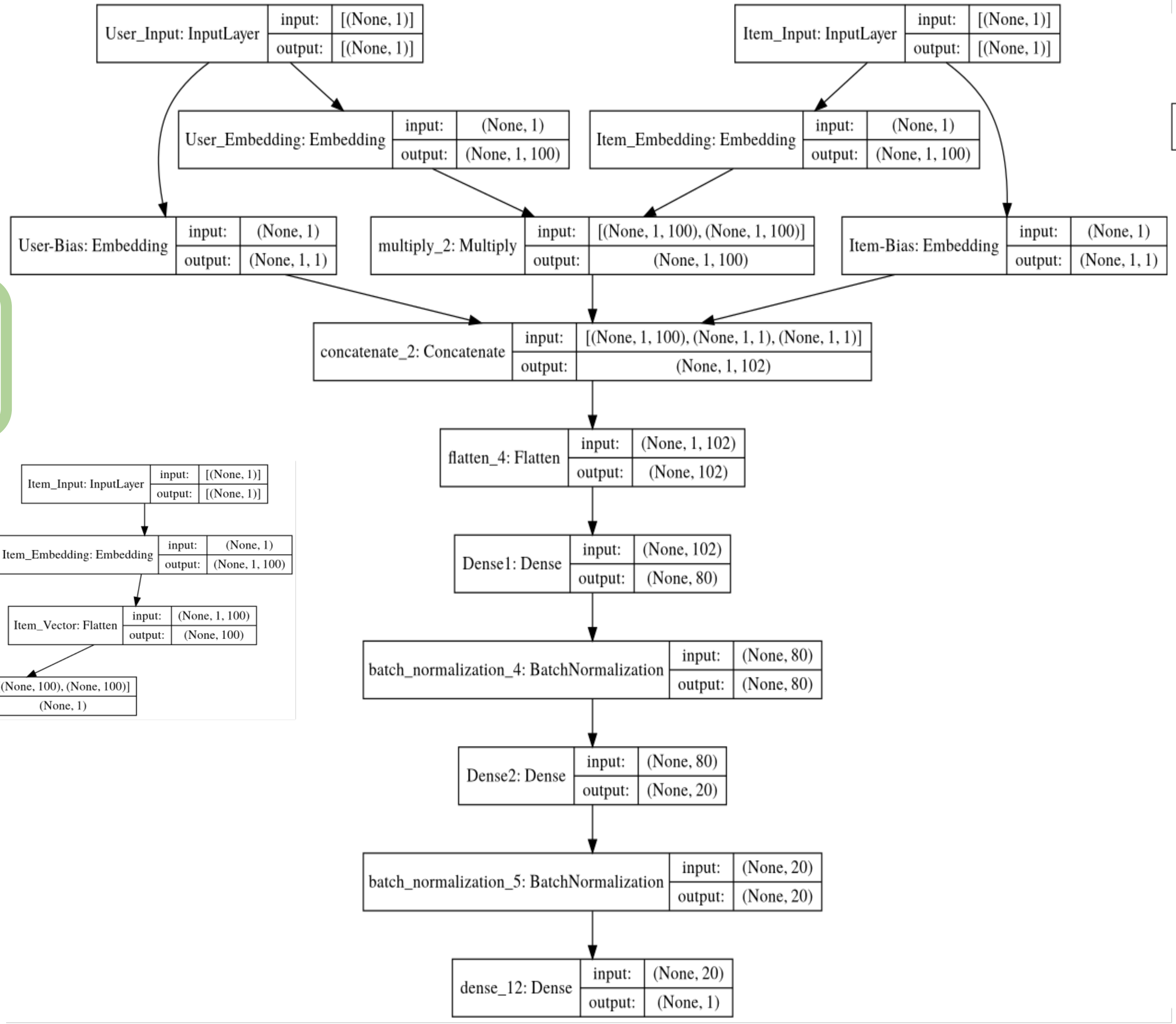
- Neural Matrix Factorization 1
- Neural Matrix Factorization 2
- Neural Matrix Factorization 3

MODELING

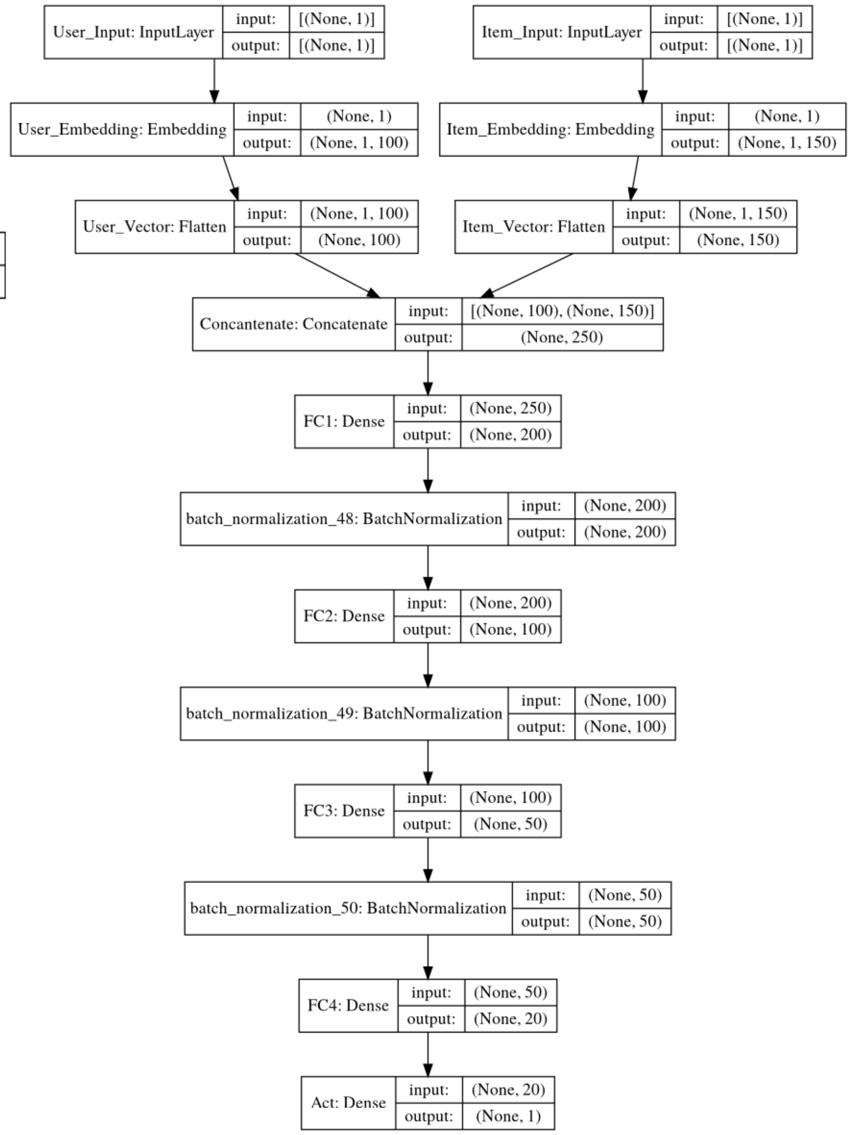
N-MF1
(Neural-Matrix Factorization)



N-MF2



N-MF3



EVALUATION OF MODELS

Model Evaluation Metrics

- **RMSE**: Root Mean Squared Error. Lower value is better.
- **MAE**: Mean Absolute Error. Lower value is better.
- **Precision@k**: number of recommended items that are actually rated within top-over number of top-k. Higher value is better.
- **Recall@**k: number of recommended items that are relevant over number of recommended items. Higher value is better.
- **HR**: Hit Rate; how often we are able to recommend a left-out rating. Higher is better.
- **cHR**: Cumulative Hit Rate; hit rate, confined to ratings above a certain threshold. Higher is better.
- **Coverage**: Ratio of users for whom recommendations above a certain threshold exist. Higher is better.
- **Diversity**:1−S, where Sis the average similarity score between every possible pair of recommendations for a given user. Higher means more diverse.
- **Novelty**: Average popularity rank of recommended items. Higher means more novel.

$$Prec@k = \frac{\text{\# of Relevant Items Recommended in top-k}}{\text{k (\# of Items that Recommended)}}$$

$$Recall@k = \frac{\text{\# of Relevant Items Recommended in top-k}}{\text{\# of Relevant Items}}$$

$$HR = \frac{\text{\# of Hit}}{\text{\# of Users}}$$

$$cHR = \frac{\text{\# of Hits of ratings above threshold}}{\text{\# of Users}}$$

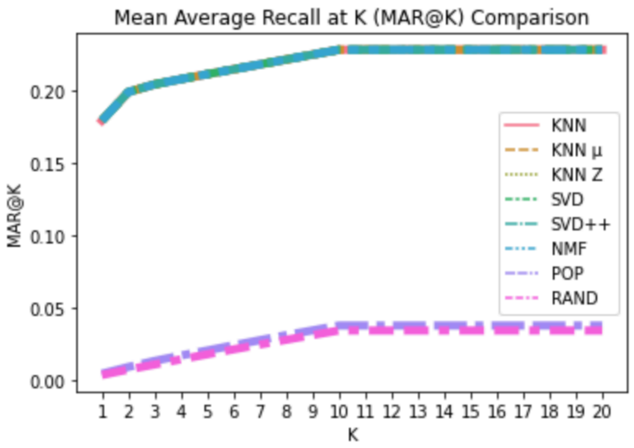
$$Cvg = \frac{\text{\# of Users above threshold}}{\text{\# of Users}}$$

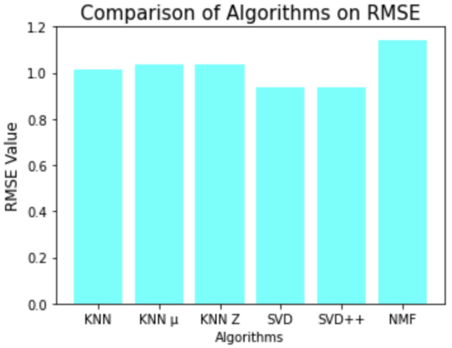
$$Dvr = 1 - S$$

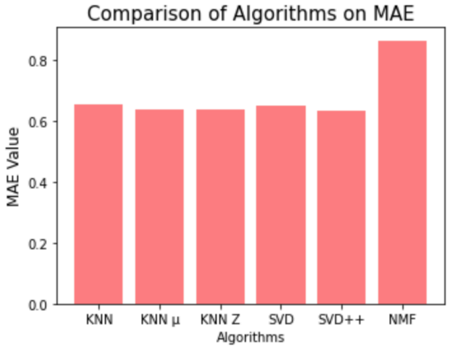
$$Nvl = \sum_{i=0}^{k} \frac{\text{Rating(i) that current User gave}}{\text{Rank(i)}}$$

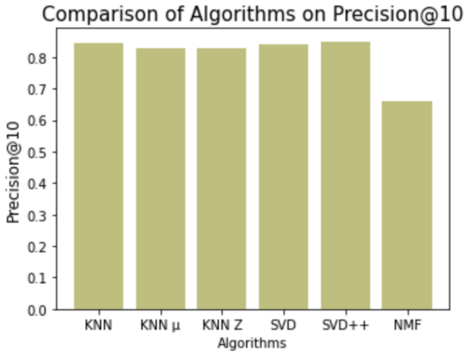
EVALUATION OF MODELS

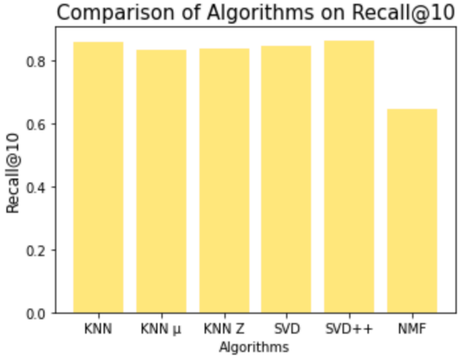
Model Performance Comparison



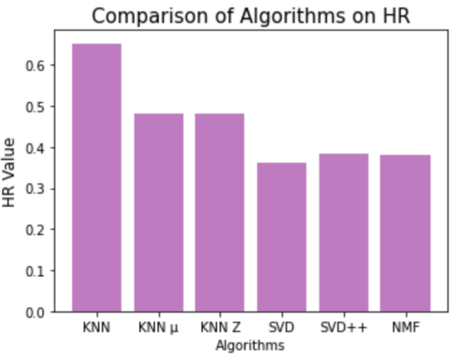


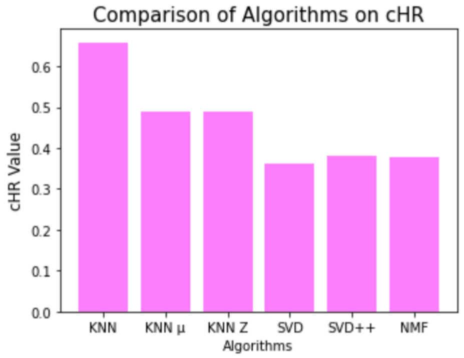


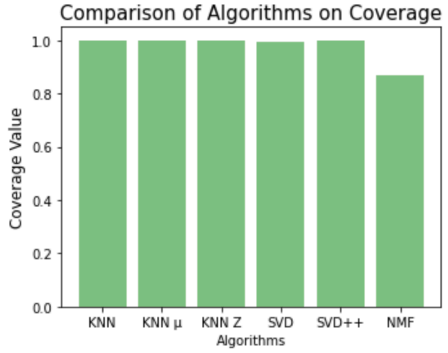


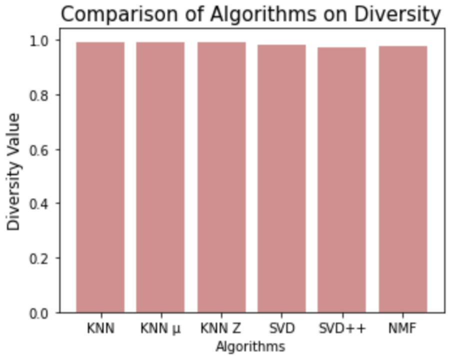


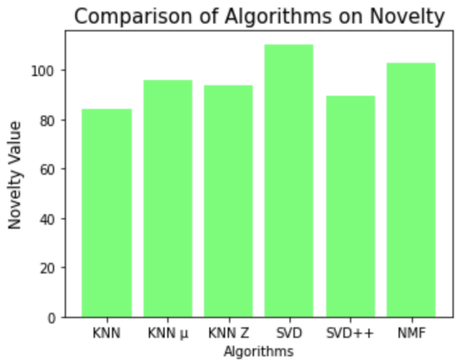
Model	RMSE	MAE	Pr@10	Re@10	HR	cHR	Cvg	Dvs	Nvl
KNN	1.012	0.656	0.843	0.857	0.652	0.659	1.0	0.991	84.2
KNN µ	1.037	0.638	0.827	0.835	0.481	0.488	1.0	0.993	96.0
KNN Z	1.037	0.641	0.829	0.836	0.480	0.488	1.0	0.993	94.1
SVD	0.935	0.651	0.838	0.848	0.360	0.361	0.99	0.980	110.5
SVD++	0.938	0.634	0.850	0.864	0.384	0.381	1.0	0.970	89.6
NMF	1.143	0.866	0.659	0.646	0.382	0.379	0.87	0.977	103.0







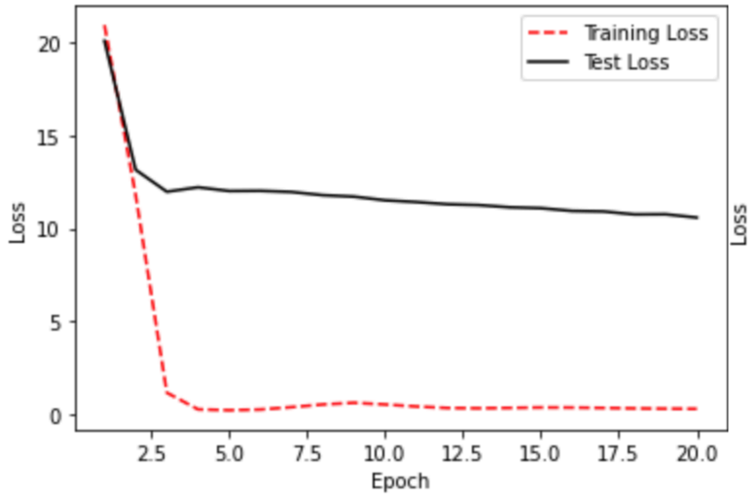




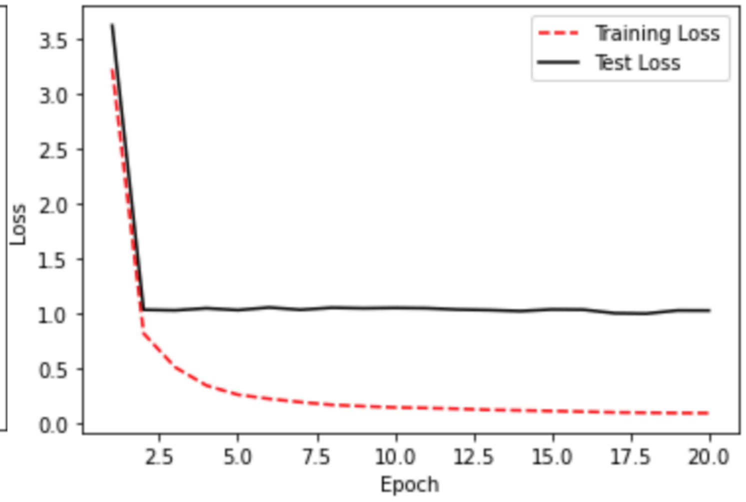
EVALUATION OF MODELS

Model Performance Comparison

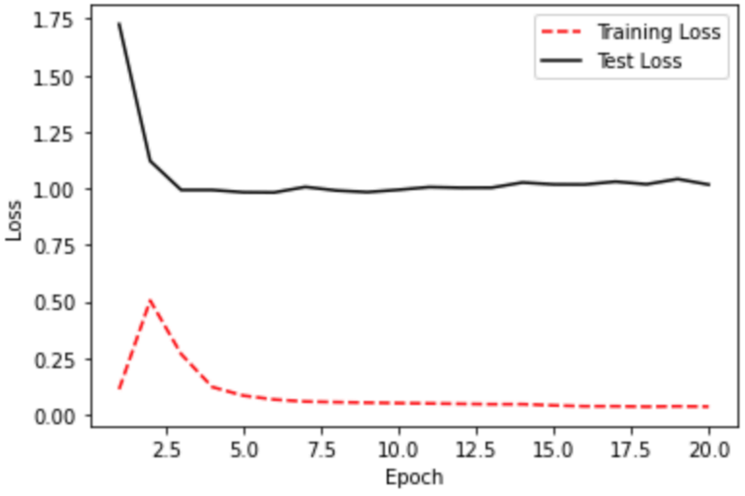
Training Loss vs. Test Loss for N-MF1



Training Loss vs. Test Loss for N-MF3



Training Loss vs. Test Loss for N-MF2



Model	RMSE
KNN	1.012
KNN µ	1.037
KNN Z	1.037
SVD	0.935
SVD++	0.938
NMF	1.143
N-MF1	3.254
N-MF2	1.008
N-MF3	1.011

N-MF1
- Underfitting

He Normal Initialization
Lower Regularization Rate
Add Bias
Add 2 Fully Connected Layers
ReLU
Batch Normalization

N-MF2
- Overfitting

He Normal Initialization
Same Regularization Rate
Concat two latents
add 4 Fully Connected Layers
ReLU
Batch Normalization

N-MF1
- Generalized (compared first two)

FUTURE WORK

- **Various Metrics**: N-MF models can be evaluated with other metrics including Rank-less and Rank-aware metrics.

NOTE: it is suggested to use Rank-less like Precision@k, Recall@k, and Hit@k, and Rank-aware like MAP(Mean Average Precision) and nDCG (normalized Discounted Cumulative Gain) with penalizing rank; red mark is the unused metrics for this projects.

- **Time Comparison**: Comparison of training time can bring more values on this project.

- **More Model Comparison**: The project can be expanded with Content-based and Hybrid Filtering.