

# Case Study 4.1 - Movies

## ADVANCED PYTHON

As this is an advanced version, we don't include a lot of code here. If you get stuck on a particular part, feel free to also use the beginner version in `beginnner_python.ipynb` to help you out.

## Identification Information

In [1]:

```
# YOUR NAME           = Ariel Arturo Goubiah Gamboa Vazquez
# YOUR MITX PRO USERNAME = goubiah
# YOUR MITX PRO E-MAIL  = goubiah@gmail.com
```

## Setup

Run these cells to install all the packages you need to complete the remainder of the case study. This may take a few minutes, so please be patient.

In [2]:

```
!pip install surprise
```

```
Collecting surprise
  Downloading
https://files.pythonhosted.org/packages/61/de/e5cba8682201fcf9c3719a6fdda9568ed061945493dea2dd37c5618b/surprise-0.1-py2.py3-none-any.whl
Collecting scikit-surprise (from surprise)
  Downloading
https://files.pythonhosted.org/packages/4d/fc/cd4210b247d1dca421c25994740cb1c5e980e31881f10eaddf45fdab0/scikit-surprise-1.0.6.tar.gz (3.3MB)
100% |████████████████████████████████████████| 3.3MB 472kB/s ta 0:00:011
Requirement already satisfied: joblib>=0.11 in
/home/nbuser/anaconda3_501/lib/python3.6/site-packages (from scikit-surprise->surprise) (0.11)
Requirement already satisfied: numpy>=1.11.2 in
/home/nbuser/anaconda3_501/lib/python3.6/site-packages (from scikit-surprise->surprise) (1.14.3)
Collecting scipy>=1.0.0 (from scikit-surprise->surprise)
  Downloading
https://files.pythonhosted.org/packages/a8/0b/f163da98d3a01b3e0ef1cab8dd2121aee2bafbb1c5bffa354cc8a1730/scipy-1.1.0-cp36-cp36m-manylinux1_x86_64.whl (31.2MB)
100% |████████████████████████████████████████| 31.2MB 59kB/s eta 0:00:011 2%
|██████████| 686kB 10.9MB/s eta 0:00:03 23% |██████████|
|██████████| 7.2MB 8.5MB/s eta 0:00:03 30% |██████████|
|██████████| 9.5MB 24.2MB/s eta 0:00:01
Requirement already satisfied: joblib>=0.11 in
```

```
Requirement already satisfied: six>=1.10.0 in
/home/nbuser/anaconda3_501/lib/python3.6/site-packages (from scikit-surpris
e->surprise) (1.11.0)
Building wheels for collected packages: scikit-surprise
  Running setup.py bdist_wheel for scikit-surprise ... done
  Stored in directory:
/home/nbuser/.cache/pip/wheels/ec/c0/55/3a28eab06b53c220015063ebdb81213cd3c
72c088251ec
Successfully built scikit-surprise
Installing collected packages: scipy, scikit-surprise, surprise
  Found existing installation: scipy 0.19.1
    Uninstalling scipy-0.19.1:
      Successfully uninstalled scipy-0.19.1
Successfully installed scikit-surprise-1.0.6 scipy-1.1.0 surprise-0.1
```

Now, you must press **Kernel > Restart**. This allows the installation to take effect. Once you see the blue **Connected/Kernel ready** button in the top right, you are good to go.

## Import

In [1]:

```
import pandas as pd
import matplotlib
from surprise import Dataset, SVD, NormalPredictor, BaselineOnly, KNNBasic,
NMF
from surprise.model_selection import cross_validate, KFold
```

## Data

Use the `Dataset.load\_builtin` function to load the data.

In [2]:

```
data = Dataset.load_builtin('ml-100k')
```

```
Dataset ml-100k could not be found. Do you want to download it? [Y/n] y
Trying to download dataset from
http://files.grouplens.org/datasets/movielens/ml-100k.zip...
Done! Dataset ml-100k has been saved to /home/nbuser/.surprise_data/ml-100k
```

We also want to get a sense of what the data looks like. Please create a histogram of all the ratings we have in the dataset.

In [3]:

```
# 1. Get the ratings file from the data object
# This is just a filename that has all the data stored in it
ratings_file = data.ratings_file

# 2. Load that table using pandas, a common python data loading tool
# We set the column names manually here
col_names = ['user_id', 'item_id', 'rating', 'timestamp']
raw_data = pd.read_table(ratings_file, names=col_names)
```

```
raw_data = pd.read_csv('ratings_1110', names_col_names,

# 3. Get the rating column
ratings = raw_data.rating

# 4. Generate a bar plot/histogram of that data
ratings.value_counts().sort_index().plot.bar(width=0.9,color='000000',edgecolor='#00FF00',linewidth=2,hatch='/',bottom = 0)
```

```
/home/nbuser/anaconda3_501/lib/python3.6/site-packages/matplotlib/font_manager.py:281: UserWarning: Matplotlib is building the font cache using fc-list. This may take a moment.
'Matplotlib is building the font cache using fc-list. '
```

Out[3]:

<matplotlib.axes.\_subplots.AxesSubplot at 0x7f749d37d390>

In [4]:

```
raw_data.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100000 entries, 0 to 99999
Data columns (total 4 columns):
user_id      100000 non-null int64
item_id      100000 non-null int64
rating       100000 non-null int64
timestamp    100000 non-null int64
dtypes: int64(4)
memory usage: 3.1 MB
```

In [5]:

```
raw_data.describe()
```

Out[5]:

	user_id	item_id	rating	timestamp
count	100000.00000	100000.000000	100000.000000	1.000000e+05
mean	462.48475	425.530130	3.529860	8.835289e+08
std	266.61442	330.798356	1.125674	5.343856e+06
min	1.00000	1.000000	1.000000	8.747247e+08
25%	254.00000	175.000000	3.000000	8.794487e+08
50%	447.00000	322.000000	4.000000	8.828269e+08
75%	682.00000	631.000000	4.000000	8.882600e+08
max	943.00000	1682.000000	5.000000	8.932866e+08

In [6]:

```
raw_data.head(10)
```

Out[6]:

	user_id	item_id	rating	timestamp
--	---------	---------	--------	-----------

0	user_id	item_id	rating	timestamp
1	186	302	3	891717742
2	22	377	1	878887116
3	244	51	2	880606923
4	166	346	1	886397596
5	298	474	4	884182806
6	115	265	2	881171488
7	253	465	5	891628467
8	305	451	3	886324817
9	6	86	3	883603013

In [7]:

```
raw_data.tail(10)
```

Out[7]:

	user_id	item_id	rating	timestamp
99990	806	421	4	882388897
99991	676	538	4	892685437
99992	721	262	3	877137285
99993	913	209	2	881367150
99994	378	78	3	880056976
99995	880	476	3	880175444
99996	716	204	5	879795543
99997	276	1090	1	874795795
99998	13	225	2	882399156
99999	12	203	3	879959583

In [8]:

```
raw_data['user_id'].value_counts().head(10)
```

Out[8]:

```
405    737
655    685
13     636
450    540
276    518
416    493
537    490
303    484
234    480
393    448
```

Name: user\_id, dtype: int64

In [9]:

```
raw_data['user_id'].value_counts().tail(10)
```

Out[9]:

93	20
732	20
475	20
571	20
596	20
147	20
19	20
572	20
636	20
895	20

Name: user\_id, dtype: int64

In [10]:

```
raw_data['item_id'].value_counts().head(10)
```

Out[10]:

50	583
258	509
100	508
181	507
294	485
286	481
288	478
1	452
300	431
121	429

Name: item\_id, dtype: int64

In [11]:

```
raw_data['item_id'].value_counts().tail(10)
```

Out[11]:

1670	1
1606	1
1520	1
1414	1
1584	1
1648	1
1571	1
1329	1
1457	1
1663	1

Name: item\_id, dtype: int64

In [12]:

```
raw_data['rating'].value_counts()
```

Out[12]:

4	34174
3	27145

```
5    21201
2    11370
1     6110
Name: rating, dtype: int64
```

In [13]:

```
sum(raw_data['user_id'].value_counts())
```

Out[13]:

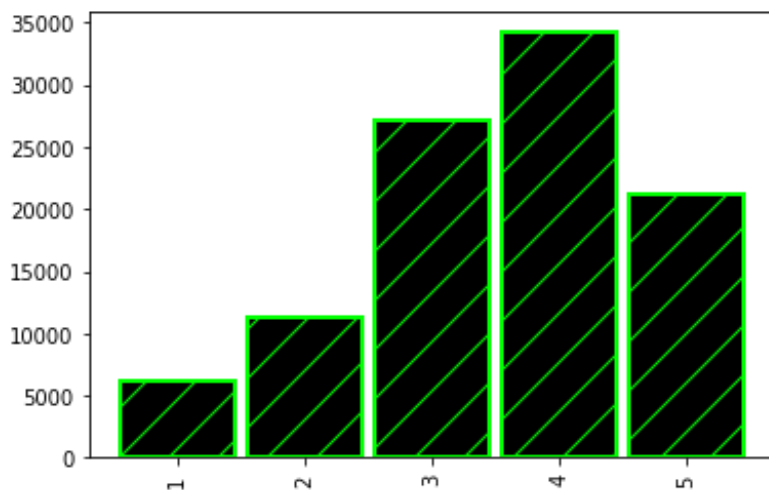
```
100000
```

In [14]:

```
ratings.value_counts().sort_index().plot.bar(width=0.9,color='000000',edgecolor='#00FF00',linewidth=2,hatch='/',bottom = 0)
```

Out[14]:

<matplotlib.axes.\_subplots.AxesSubplot at 0x7f749cb8e0b8>

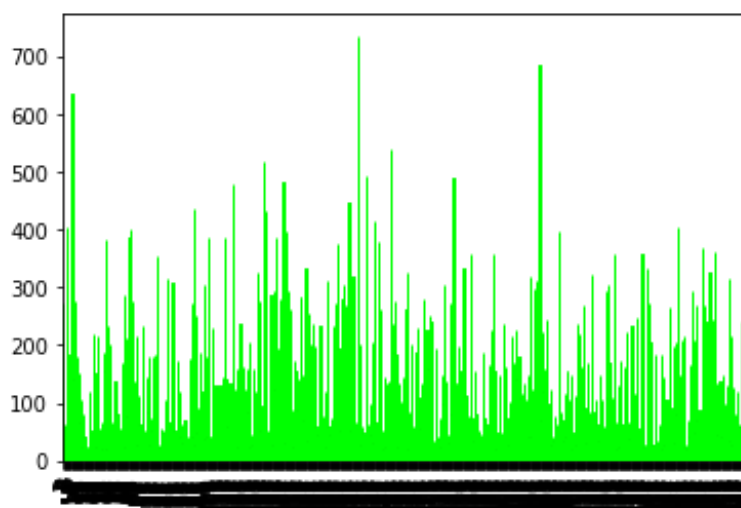


In [15]:

```
raw_data['user_id'].value_counts().sort_index().plot.bar(color='000000',edgecolor='#00FF00',hatch='/',bottom = 0)
```

Out[15]:

<matplotlib.axes.\_subplots.AxesSubplot at 0x7f749cbadb00>

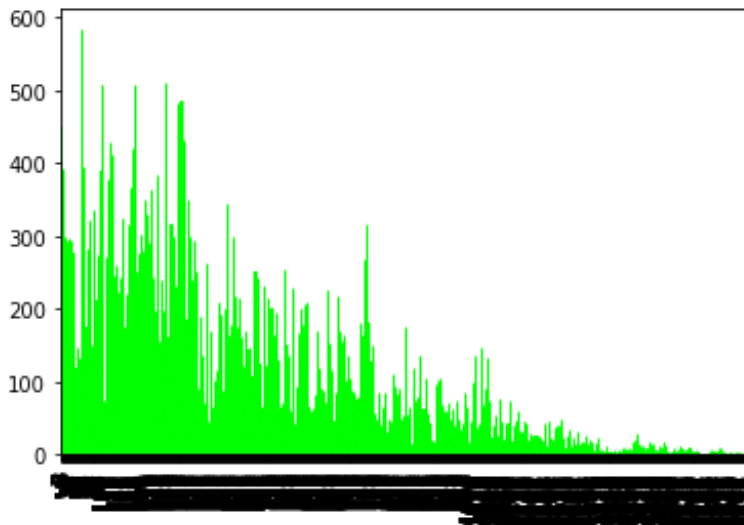


In [16]:

```
raw_data['item_id'].value_counts().sort_index().plot.bar(color='000000',edgecolor='#00FF00',hatch='/',bottom = 0)
```

Out[16]:

<matplotlib.axes.\_subplots.AxesSubplot at 0x7f749cab5da0>



## QUESTION 1: DATA ANALYSIS

**Describe the dataset. How many ratings are in the dataset? How would you describe the distribution of ratings? Is there anything else we should observe? Make sure the histogram is visible in the notebook.**

The dataset we imported has 100,000 ratings that are given in the form: user\_id item\_id rating timestamp. That are related each one to a User, Movie, Rating that the user gives to the movie and the timestamp of the rating.

The **histogram** shows that most of the ratings given are a 4 out of 5 with more than one third of the total ratings given.

The **number of ratings given per user** seems **disperse**, we have users that have rated over 700 movies and we have users that have rated only 20 movies.

Also the **rating of the movies** movies are disperse, since we have movies rated only once and we have movies that have been rated more than 400 times

## Model 1: Random

In [17]:

```
# Create model using NormalPredictor() class
model_random = NormalPredictor()
```

In [18]:

```
# Train on data using cross-validation with k=5 folds, measuring the RMSE
# See the cross validate function that we have imported above
```

```
# See the cross_validate function that we have imported above
#
http://surprise.readthedocs.io/en/stable/model\_selection.html#surprise.model\_selection.validation.cross\_validate
model_random_results = cross_validate(model_random, data, measures=['RMSE'],
, cv=5, verbose=True)
```

Evaluating RMSE of algorithm NormalPredictor on 5 split(s).

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Std
RMSE (testset)	1.5237	1.5102	1.5150	1.5077	1.5137	1.5141	0.0055
Fit time	0.92	0.90	1.05	0.93	0.90	0.94	0.05
Test time	1.68	1.26	1.19	1.31	1.18	1.33	0.19

In [19]:

```
sum(model_random_results['test_rmse'])/len(model_random_results['test_rmse'])
```

Out[19]:

1.5140673236869597

## Model 2: User-Based Collaborative Filtering

In [20]:

```
# Create model using KNNBasic() class
# See the sim_options parameter to determine the user/item similarity calculation of the model
#
http://surprise.readthedocs.io/en/stable/prediction\_algorithms.html#similar-measures-configuration
model_user = KNNBasic(sim_options={'user_based': True})
```

In [21]:

```
# Train using same cross validation code as above
model_user_results = cross_validate(model_user, data, measures=['RMSE'], cv=5, verbose=True)
```

Computing the msd similarity matrix...  
 Done computing similarity matrix.  
 Computing the msd similarity matrix...  
 Done computing similarity matrix.  
 Computing the msd similarity matrix...  
 Done computing similarity matrix.  
 Computing the msd similarity matrix...  
 Done computing similarity matrix.  
 Computing the msd similarity matrix...  
 Done computing similarity matrix.  
 Evaluating RMSE of algorithm KNNBasic on 5 split(s).

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Std
RMSE (testset)	0.9781	0.9832	0.9795	0.9818	0.9739	0.9793	0.0032
Fit time	3.26	3.15	3.22	3.28	3.11	3.20	0.07
Test time	29.45	28.53	26.79	28.26	28.02	28.21	0.86



In [22]:

```
sum(model_user_results['test_rmse'])/len(model_user_results['test_rmse'])
```

Out[22]:

0.9793073104991794

## Model 3: Item-Based Collaborative Filtering

In [23]:

```
# Create model using KNNBasic() class
# Make sure you change the sim_options parameter from above
model_item = KNNBasic(sim_options={'user_based': False})
```

In [24]:

```
# Train using same cross validation code as above
model_item_results = cross_validate(model_item, data, measures=['RMSE'], cv
=5, verbose=True)
```

```
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Evaluating RMSE of algorithm KNNBasic on 5 split(s).
```

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Std
RMSE (testset)	0.9763	0.9756	0.9768	0.9686	0.9732	0.9741	0.0030
Fit time	5.25	5.39	4.10	3.88	5.09	4.74	0.62
Test time	28.61	31.00	28.77	33.69	33.72	31.16	2.24

In [25]:

```
sum(model_item_results['test_rmse'])/len(model_item_results['test_rmse'])
```

Out[25]:

0.9740999442282998

## QUESTION 2: COLLABORATIVE FILTERING MODELS

Compare the results from the user-user and item-item models. How do they compare to each other? How do they compare to our original "random" model? Can you provide any intuition as to why the results came out the way they did?

The **user to user** and the **item to item** models performed significantly better than the **random** model; this happens because the random model does not take into consideration a very large portion

of the information provided by the dataset, so it makes sense that the result of the random model performs far worse. Between the user-user and the item-item models, it is hard to tell which one is better because their performance is good, and it does not meaningfully change from one to the other.

We can see that the RMSE of the item to item approach is a little bit better than the user to user (RMSE is 0.9788 for the user to user model and 0.9751 for the item to item model), but it took a little more time to compute; so that can be an advantage for the user to user model. For a dataset that has even more data points, we can think that the item to item model would converge more, and we could even try doing the model offline, leaving outside our model some fresh data points. And with more data points, we can expect the behaviour of the user to user model to diverge thanks to the dynamic nature of people.

Type your response here...

## Model 4: Matrix Factorization

In [26]:

```
# Create model using SVD() class
model_matrix = SVD()
```

In [27]:

```
# Train using same cross validation code as above
model_matrix_results = cross_validate(model_matrix, data, measures=['RMSE'],
, cv=5, verbose=True)
```

Evaluating RMSE of algorithm SVD on 5 split(s).

	Fold 1	Fold 2	Fold 3	Fold 4	Fold 5	Mean	Std
RMSE (testset)	0.9393	0.9463	0.9289	0.9340	0.9346	0.9366	0.0059
Fit time	38.91	40.74	42.83	41.16	40.49	40.83	1.26
Test time	1.65	2.64	1.43	1.39	2.15	1.85	0.48

In [28]:

```
sum(model_matrix_results['test_rmse'])/len(model_matrix_results['test_rmse'])
```

Out [28]:

0.9366370553206149

## QUESTION 3: MATRIX FACTORIZATION MODEL

The matrix factorization model is different from the collaborative filtering models. Briefly describe this difference. Also, compare the RMSE again. Does it improve? Can you offer any reasoning as to why that might be?

The matrix factorization model's performance is even better than the user to user or the item to item, but it takes more time to converge. Basically how the matrix factorization model works, is that it factors a Matrix A into simpler versions and applies stochastic gradient descent there to minimize the squared error. At the moment of factorization, our model works with noise but also in higher dimensions; this

process helps you find latent features within the data, and the gradient descent helps to reduce the error input by the noise added in the factorization process.

## Precision and Recall @ k

We now want to compute the precision and recall for 2 values of  $k$ : 5 and 10. We have provided some code here to help you do that.

First, we define a function that takes in some predictions, a value of  $k$  and a threshold parameter. This code is adapted from [here](#).

In [29]:

```
def precision_recall_at_k(predictions, k=10, threshold=3.5):
    '''Return precision and recall at k metrics for each user.'''

    # First map the predictions to each user.
    user_est_true = dict()
    for uid, _, true_r, est, _ in predictions:
        current = user_est_true.get(uid, list())
        current.append((est, true_r))
        user_est_true[uid] = current

    precisions = dict()
    recalls = dict()
    for uid, user_ratings in user_est_true.items():

        # Sort user ratings by estimated value
        user_ratings.sort(key=lambda x: x[0], reverse=True)

        # Number of relevant items
        n_rel = sum((true_r >= threshold) for (_, true_r) in user_ratings)

        # Number of recommended items in top k
        n_rec_k = sum((est >= threshold) for (est, _) in user_ratings[:k])

        # Number of relevant and recommended items in top k
        n_rel_and_rec_k = sum(((true_r >= threshold) and (est >=
threshold))
                                for (est, true_r) in user_ratings[:k]))

        # Precision@K: Proportion of recommended items that are relevant
        precisions[uid] = n_rel_and_rec_k / n_rec_k if n_rec_k != 0 else 1

        # Recall@K: Proportion of relevant items that are recommended
        recalls[uid] = n_rel_and_rec_k / n_rel if n_rel != 0 else 1

    return precisions, recalls
```

In [30]:

```
# Make list of k values
K = [5, 10]

# Make list of models
models = [model_random, model_user, model_item, model_matrix]
```

```

# Create k-fold cross validation object
kf = KFold(n_splits=5)
metrics = {}
indicators = {}
for k in K:
    print('***** Iterating with k =' + str(k) +
          '*****')
    counter = 1
    metrics[k] = {}
    indicators[k] = {}
    for model in models:
        print('***** Model number ' + str(counter))
        # Run folder and take average
        p = []
        r = []
        metrics[k][counter] = {}
        indicators[k][counter] = {}
        for trainset, testset in kf.split(data):
            model.fit(trainset)
            predictions = model.test(testset, verbose=False)
            precisions, recalls = precision_recall_at_k(predictions, k=k, th
reshold=3.5)

            # Precision and recall can then be averaged over all users
            p.append(sum(prec for prec in precisions.values()) / len(precisi
ons))
            r.append(sum(rec for rec in recalls.values()) / len(recalls))

        print('>>> precision:', round(sum(p) / len(p), 3))
        print('>>> reccall  :', round(sum(r) / len(r), 3))
        metrics[k][counter]['p'] = p
        metrics[k][counter]['r'] = r
        indicators[k][counter]['p'] = sum(p) / len(p)
        indicators[k][counter]['r'] = sum(r) / len(r)
        counter = counter + 1

```

```

***** Iterating with k =5*****
***** Model number 1
>>> precision: 0.58
>>> reccall  : 0.342
***** Model number 2
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
>>> precision: 0.761
>>> reccall  : 0.457
***** Model number 3
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...

```

```

Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
>>> precision: 0.816
>>> reccall : 0.39
***** Model number 4
>>> precision: 0.784
>>> reccall : 0.432
***** Iterating with k =10*****
***** Model number 1
>>> precision: 0.595
>>> reccall : 0.436
***** Model number 2
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
>>> precision: 0.736
>>> reccall : 0.592
***** Model number 3
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
Computing the msd similarity matrix...
Done computing similarity matrix.
>>> precision: 0.793
>>> reccall : 0.535
***** Model number 4
>>> precision: 0.754
>>> reccall : 0.561

```

In [31]:

```

indicators['rmse']={}
indicators['rmse']
[1]=sum(model_random_results['test_rmse'])/len(model_random_results['test_r
mse'])
indicators['rmse']
[2]=sum(model_user_results['test_rmse'])/len(model_user_results['test_rmse'
])
indicators['rmse']
[3]=sum(model_item_results['test_rmse'])/len(model_item_results['test_rmse'
])
indicators['rmse']
[4]=sum(model_matrix_results['test_rmse'])/len(model_matrix_results['test_r
mse'])

```

In [32]:

```
indicators[5]
```

Out[32]:

```
{1: {'p': 0.579717198403918, 'r': 0.3415732351421551},
 2: {'p': 0.7606185171082689, 'r': 0.4572157120554599},
 3: {'p': 0.8163739885926928, 'r': 0.389626312830023},
 4: {'p': 0.7840626017383905, 'r': 0.43243975914055977}}
```

In [33]:

```
indicators[10]
```

Out[33]:

```
{1: {'p': 0.5946166317771169, 'r': 0.43599201876176147},
 2: {'p': 0.7362875239763655, 'r': 0.5917957758657505},
 3: {'p': 0.7932377113466316, 'r': 0.5346169868476462},
 4: {'p': 0.7536485904456933, 'r': 0.5613624970971106}}
```

In [34]:

```
indicators['rmse']
```

Out[34]:

```
{1: 1.5140673236869597,
 2: 0.9793073104991794,
 3: 0.9740999442282998,
 4: 0.9366370553206149}
```

In [35]:

```
indicators['rmse'][1]
```

Out[35]:

```
1.5140673236869597
```

In [36]:

```
def resultsTable():
    print('Overall ranking')

    print('\t\t\t P@5\t\tP@10\t\tR@5\t\tR@10\t\tRMSE')
    print('RandomModel \t\t\t'
          +str(round(indicators[5][1]['p'],3))
          +'\t\t\t'
          +str(round(indicators[10][1]['p'],3))
          +'\t\t\t'
          +str(round(indicators[10][1]['r'],3))
          +'\t\t\t'
          +str(round(indicators[10][1]['r'],3))
          +'\t\t\t'
          +str(round(indicators['rmse'][1],3))
    )
    print('User2User \t\t\t'
          +str(round(indicators[5][2]['p'],3))
          +'\t\t\t'
          +str(round(indicators[10][2]['p'],3))
          +'\t\t\t'
```

```

        +str(round(indicators[10][2]['r'],3))
        +'\t\t'
        +str(round(indicators[10][2]['r'],3))
        +'\t\t'
        +str(round(indicators['rmse'][2],3))
    )
    print('Item2Item \t\t'
        +str(round(indicators[5][3]['p'],3))
        +'\t\t'
        +str(round(indicators[10][3]['p'],3))
        +'\t\t'
        +str(round(indicators[10][3]['r'],3))
        +'\t\t'
        +str(round(indicators[10][3]['r'],3))
        +'\t\t'
        +str(round(indicators['rmse'][3],3))
    )
    print('MatrixFact \t\t'
        +str(round(indicators[5][4]['p'],3))
        +'\t\t'
        +str(round(indicators[10][4]['p'],3))
        +'\t\t'
        +str(round(indicators[10][4]['r'],3))
        +'\t\t'
        +str(round(indicators[10][4]['r'],3))
        +'\t\t'
        +str(round(indicators['rmse'][4],3))
    )

```

Next, we compute the precision and recall at  $k = 5$  and 10 for each of our 4 models. We use 5-fold cross validation again to average the results across the entire dataset.

Please note that this will take some time to compute.

## QUESTION 4: PRECISION/RECALL

**Compute the precision and recall, for each of the 4 models, at  $k = 5$  and 10. This is  $2 \times 2 \times 4 = 16$  numerical values. Do you note anything interesting about these values? Anything different from the RMSE values you computed above?**

Some code is required for this question.

In [37]:

```

# Use the function above to compute the 16 numerical values requested above
# See the test() function to get the predictions input to the function
#
http://surprise.readthedocs.io/en/stable/algo\_base.html#surprise.prediction\_
orithms.algo\_base.AlgoBase.test

#***** Please not ethat the code is above the
question, here I just want to show a table that
#***** I built to see the results more clearl
y.

```

```
resultsTable()
```

Overall ranking

	P@5	P@10	R@5	R@10	RMSE	
RandomModel		0.58	0.595	0.436	0.436	1.514
User2User	0.761		0.736	0.592	0.592	0.979
Item2Item	0.816	0.793		0.535	0.535	0.974
MatrixFact	0.784	0.754	0.561	0.561		0.937

As it is expected, the **Random Model has the worst performance of all the models** reviewed in the case study. This model has the highest RMSE, and the lowest of the Precision and Recall metrics, this can be easily explained because of the simplicity of the model.

The best performing model for the RMSE metric is the Matrix Factorization Model, and this can also be easily explained since the Gradient Descent algorithm takes into consideration the optimization of the squared error, affecting directly the RMSE value.

If we take into **consideration** the **precision and the recall**, the **item to item** model is the one that shows the **best** results for both cases.

As I mentioned in the answer number 2, the User to User model tends to diverge in large amounts of data, as the behaviour of the other collaborative method tends to do the opposite, so it makes sense that the User to User model has a worse performance than the Item to Item model.

Apparently, collaborative filtering methods have a better performance on the precision and recall metrics since it takes into consideration the affinity between users or items, that are relationships that do not have much weight in the Matrix Factorization Model.

## Top-n Predictions

Finally, we can see what some of the actual movie ratings are for particular users, as outputs of our model.

Again, we define a helpful function.

In [38]:

```
def get_top_n(predictions, n=5):  
    '''Return the top-N recommendation for each user from a set of predictions.  
  
    Args:  
        predictions(list of Prediction objects): The list of predictions, as  
        returned by the test method of an algorithm.  
        n(int): The number of recommendation to output for each user. Default  
        is 10.  
  
    Returns:  
    A dict where keys are user (raw) ids and values are lists of tuples:  
        [(raw item id, rating estimation), ...] of size n.  
    '''
```



```

# First map the predictions to each user.
top_n = dict()
for uid, iid, true_r, est, _ in predictions:
    current = top_n.get(uid, [])
    current.append((iid, est))
    top_n[uid] = current

# Then sort the predictions for each user and retrieve the k highest ones.
for uid, user_ratings in top_n.items():
    user_ratings.sort(key=lambda x: x[1], reverse=True)
    top_n[uid] = user_ratings[:n]

return top_n

```

In [39]:

```

trainset = data.build_full_trainset()
testset = trainset.build_anti_testset()

```

In [41]:

```

counter = 1
tops = []
for model in models:
    print('***** Working wiht the model number' + str(counter))
    model.fit(trainset)
    predictions = model.test(testset)
    top_n = get_top_n(predictions, n=5)
    tops.append(top_n)
    # Print the first one
    user = list(top_n.keys())[0]
    print(f'model: {model}, {user}: {top_n[user]}')
    counter = counter + 1

```

```

***** Working wiht the model number1
model: <surprise.prediction_algorithms.random_pred.NormalPredictor object at 0x7f749cbb2470>, 196: [('193', 5), ('88', 5), ('564', 5), ('196', 5), ('143', 5)]
***** Working wiht the model number2
Computing the msd similarity matrix...
Done computing similarity matrix.
model: <surprise.prediction_algorithms.knns.KNNBasic object at 0x7f74a4fc63c8>, 196: [('1189', 5), ('1500', 5), ('814', 5), ('1536', 5), ('1599', 5)]
***** Working wiht the model number3
Computing the msd similarity matrix...
Done computing similarity matrix.
model: <surprise.prediction_algorithms.knns.KNNBasic object at 0x7f7472f26a20>, 196: [('1414', 4.666666666666667), ('1309', 4.5), ('1310', 4.5), ('1675', 4.333333333333333), ('1676', 4.3076923076923075)]
***** Working wiht the model number4
model: <surprise.prediction_algorithms.matrix_factorization.SVD object at 0x7f749cfbae80>, 196: [('64', 4.64979831464442), ('187', 4.563138932671485), ('50', 4.551788988459624), ('483', 4.546458638354643), ('169', 4.508935727973823)]

```

In [62]:

predictions

Out[62]:

```
[Prediction(uid='196', iid='302', r_ui=3.52986, est=4.069748875208385, details={'was_impossible': False}),
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```

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Out[57]:

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Then, we call this function on each of our models, first training on **all** the data we have available, then predicting on the remaining, missing data. We use `n=5` here, but you can pick any reasonable value of `n` you would like.

This may take some time to compute, so be patient.

Hint: Use `\*\*Dataset.build\_full\_trainset\*\*` to get the full trainset from the data. Then call `\*\*Trainset.build\_anti\_testset\*\*` to get the testset out. Finally, `fit` on the trainset, `test` on the testset, then pass that result to our `get_top_n` function.

## QUESTION 5: TOP N PREDICTIONS

**Do the top `n` predictions that you received make sense? What is the rating value (1-5) of these predictions? How could you use these predictions in the real-world if you were trying to build a generic content recommender system for a company?**

Some code is required for this question.

In [ ]:

```
# Use the function and hints above to give the top-n predictions for a  
given user, for a reasonable value of n
```

The top predictions make sense, since they are rated very close to 5 for each one of the models. This data could be used in a **generic recommender system** to make suggestions to each user, giving them the top rated items calculated. It would be a matter of testing which model gives better results, taking into consideration that it is probable that some models may need some changes depending on the performance of the system, and also the desired results for the company. In this case we got the top 5 predictions for each user, but we can enumerate many more and group this recommendations in sections or even get the **top `n` items for user in categories**, just like netflix does; if you enter to a certain category, the system will retrieve the top recommendations for you under that category, depending on the information you already fed the system.

---

Great job! Now, make sure you check out the **Conclusion** section of the [instruction manual](#) to wrap up this case study properly.