user-based

October 30, 2021

[ ]:
```
import numpy as np
import pandas as pd
from scipy import stats
import matplotlib.pyplot as plt
import seaborn as sb
```

0.1 Read file and display some data

[ ]:
```
names = ['userid', 'itemid', 'rating', 'timestamp']
raw_data = pd.read_csv('./ml-100k/u.data', sep='\t', names=names)

print('Count of ratings', len(raw_data))
print('First ten rows')
print(raw_data[0:10])

# save data in a numpy array where each user ratings have their own rows
userids = sorted(list(raw_data['userid'].unique()))
itemids = sorted(list(raw_data['itemid'].unique()))

# first save in list of lists, use None values if user has not rated item
data = [[None] * len(itemids) for x in range(len(userids))]

# find ratings made by each user
for i in range(len(userids)):
    # dict of ratings for user i+1 (key = itemid, value = rating)
    user_ratings = dict(zip(raw_data.loc[raw_data['userid'] == (i+1)].itemid,␣
 ↪raw_data.loc[raw_data['userid'] == (i+1)].rating))
    for j in range(len(itemids)):
        # check if user has rated item with id j+1
        if j+1 in user_ratings:
            data[i][j] = user_ratings[j+1]

data = np.array(data)
```

```
Count of ratings 100000
First ten rows
   userid  itemid  rating  timestamp
0     196     242       3  881250949
```

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

0.2 User-based collaborativve filtering approach using Pearson correlation function

[ ]:
```
# a, b = userids, data = whole data set
def pearson_correlation(a, b, data):
    # ratings of users a and b
    data_a = data[a-1] # remember that indexing starts from 0, but userids from 1
    data_b = data[b-1]

    # dicts with itemids and ratings
    dict_a = {i: r for i, r in enumerate(data_a, start=1) if r is not None}
    dict_b = {i: r for i, r in enumerate(data_b, start=1) if r is not None}

    # intersections of common itemids
    P = list(set(dict_a).intersection(set(dict_b)))

    # keep only common itemids
    dict_a = {id: dict_a[id] for id in P}
    dict_b = {id: dict_b[id] for id in P}

    mean_a = np.mean(list(dict_a.values()))
    mean_b = np.mean(list(dict_b.values()))

    n = 0
    d1 = 0
    d2 = 0

    # calculate sums
    for item in P:
        n += ((dict_a[item] - mean_a) * (dict_b[item] - mean_b))
        d1 += ((dict_a[item] - mean_a) ** 2)
        d2 += ((dict_b[item] - mean_b) ** 2)

    # handle cases where n == 0 and d might be zero as well
    if n == 0:
        return 0
```

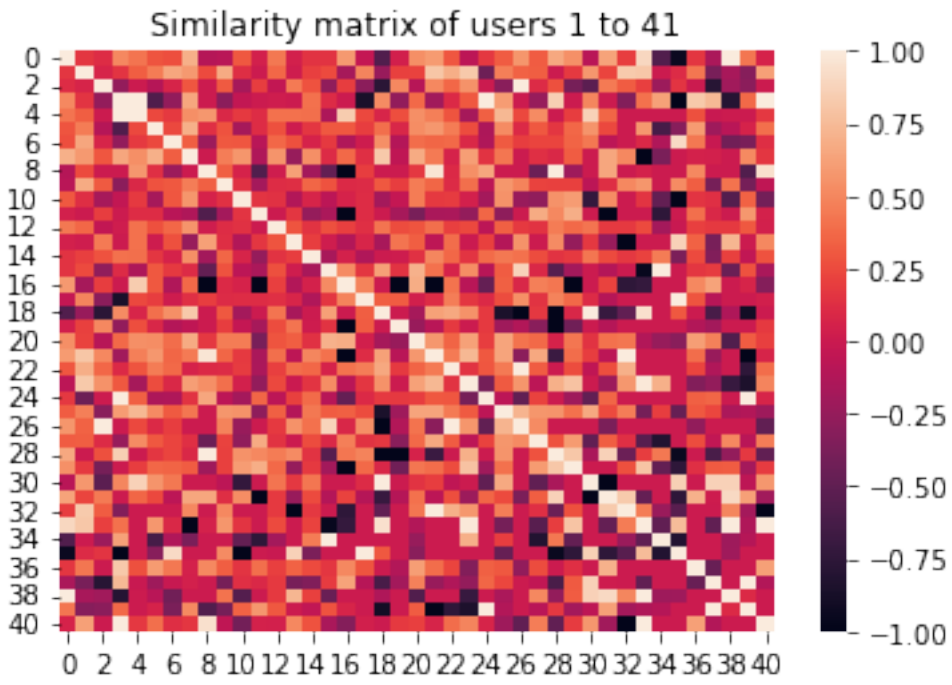
```
    sim = n / (np.sqrt(d1) * np.sqrt(d2))

    # TEST CODE TO CHECK CALCULATIONS, REMOVE BEFORE SUBMISSION?
    # compare to scipys result, with some values the 16th decimal can be␣
 ↪different -> round to 10 decimal places
    #scipy_sim, p = stats.pearsonr(list(dict_a.values()), list(dict_b.values()))
    #if np.round(sim, 10) == np.round(scipy_sim, 10):
    #    print(sim, scipy_sim)
    #    print('all ok')

    return sim
```

Similarity matrix of all users (makes later calculations faster)

[ ]:
```
sim_matrix = [[1] * len(userids) for x in range(len(userids))]
for i in range(len(userids)):
    for j in range(i+1, len(userids)):
        sim_matrix[i][j] = sim_matrix[j][i] = pearson_correlation(i+1, j+1,␣
 ↪data)

sim_matrix = np.array(sim_matrix)
```

```
/home/vaino/anaconda3/envs/recommender/lib/python3.9/site-
packages/numpy/core/fromnumeric.py:3440: RuntimeWarning: Mean of empty slice.
  return _methods._mean(a, axis=axis, dtype=dtype,
/home/vaino/anaconda3/envs/recommender/lib/python3.9/site-
packages/numpy/core/_methods.py:189: RuntimeWarning: invalid value encountered
in double_scalars
  ret = ret.dtype.type(ret / rcount)
```

[ ]:
```
# test with smaller data size (41 users)
test_matrix = [[1] * int(len(userids)/23) for x in range(int(len(userids)/23))]
for i in range(int(len(userids)/23)):
    for j in range(i+1, int(len(userids)/23)):
        test_matrix[i][j] = test_matrix[j][i] = pearson_correlation(i+1, j+1,␣
 ↪data)

test_matrix = np.array(test_matrix)

# heatmap of the similarity matrix
sb.heatmap(test_matrix)
plt.title('Similarity matrix of users 1 to 41')
plt.show()
```



0.3 Prediction function for predicting movie scores

[ ]:
```
# a = userid, p = itemid, data = whole data set,
# sim = similarity matrix t = similarity threshold
def pearson_predict(a, p, data, sim_matrix, t):
    sim = sim_matrix[a-1]
    # mean of ratings given by user a
    mean_a = np.mean([r for r in data[a-1] if r is not None])

    # transform similarities to dict (key = userid, value = similarity) and␣
 ↪filter out unvanted similarities
    sim = {i: s for i, s in enumerate(sim, start=1) if s >= t}

    n = 0
    d = 0

    for b in sim:
        # chekc if user b has not rated the item
        if data[b-1][p-1] == None:
            continue

        mean_b = np.mean([r for r in data[b-1] if r is not None])
        n += sim[b] * (data[b-1][p-1] - mean_b)
        d += sim[b]
```

```
    if n == 0:
        return mean_a

    return mean_a + n/d
```

0.4 Show n most similar users for any given user

[ ]:
```
def n_most_similar_users(n, sim):
    # transform similarities to dict (key = userid, value = similarity)
    sim = {i: s for i, s in enumerate(sim, start=1)}

    # sort similarities based on dict values and return n highest values
    sim = dict(sorted(sim.items(), key=lambda x: x[1], reverse=True))
    return dict(list(sim.items())[:n])
```

0.5 Ten most similar users to user 345

[ ]:
```
USER = 15
n = 10
users = n_most_similar_users(n, sim_matrix[USER-1])
df = pd.DataFrame(list(zip(list(users.keys()), list(users.values()))),␣
 ↪columns=['userid', 'similarity'])
print(df)
```

```
   userid  similarity
0      51    1.000000
1     700    1.000000
2      15    1.000000
3     218    1.000000
4     358    1.000000
5     369    1.000000
6     225    1.000000
7     685    0.948683
8     609    0.911967
9     607    0.904534
```

0.6 Recommended 20 movies for the same user

[ ]:
```
# find items the user has not rated
items = [m for m, r in enumerate(data[USER-1], start=1) if r is None]

predictions = {}

for item in items:
    predictions[item] = pearson_predict(USER, item, data, sim_matrix, 0.0)

# sort predictions and take 20 highest
```

```
most_relevant = dict(sorted(predictions.items(), key=lambda x: x[1],␣
↪reverse=True))
df = pd.DataFrame(list(zip(list(most_relevant.keys()), list(most_relevant.
↪values()))), columns=['itemid', 'rating pred'])[:20]
print(df)
```

```
    itemid  rating pred
0      814     4.777516
1      851     4.777516
2     1306     4.498188
3     1467     4.450920
4     1639     4.422513
5     1599     4.293251
6     1463     4.235755
7     1653     4.169118
8     1449     4.127166
9     1398     4.105663
10    1500     4.104449
11    1062     4.060307
12     853     4.050087
13    1125     4.008254
14    1512     4.006530
15    1155     3.978898
16    1585     3.966971
17    1636     3.966971
18    1642     3.966971
19    1645     3.966971
```

[ ]: