In [1]:

```python
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from scipy import stats
from dataclasses import dataclass, field
from typing import List
from matplotlib.lines import Line2D
import math
```

In [2]:

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

# 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.
    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)

# Read movie name and genre data
genres = pd.read_csv('./ml-100k/u.genre', sep='|', names=['genre', 'id'])
genres = genres['genre'].tolist()
names = ['itemid', 'name', 'date', 'moviedate', 'url'] + genres
item_data = pd.read_csv('./ml-100k/u.item', sep='|', names=names, encoding = "ISO-8859-
```

In [3]:

```python
# Movie data class, saves movie name and genres it belongs to

@dataclass
class Movie:
    id: int
    title: str
    genres: List[str] = field(default_factory=list)

movies = []

for id in itemids:
    item = item_data.loc[item_data['itemid'] == id].values.tolist()[0]

    tmp_genres = []
    i = 0
    for g in item[5:]:
        belongs = g
        if belongs:
            tmp_genres.append(genres[i])
        i += 1

    movies.append(Movie(id, item[1], tmp_genres))
```

User-based collaborative filtering approach from Assignment 1

In [4]:

```
# a, b = userids, data = whole data set
def similarity(a,b, data):
    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)))

    if len(P) < 2:
        return 0

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

    # Create constants
    const_a = list(dict_a.values())
    const_b = list(dict_b.values())

    sim, p = stats.pearsonr(const_a, const_b)

    # Check for NaN
    if sim != sim:
        return 0
    return sim
```

In [5]:

```
# Similarity matrix
N = 0
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] = similarity(i+1, j+1, data)

sim_matrix = np.array(sim_matrix)
```

```
B:\Anaconda\envs\recommender\lib\site-packages\scipy\stats\stats.py:4023: PearsonRConsta
ntInputWarning: An input array is constant; the correlation coefficient is not defined.
  warnings.warn(PearsonRConstantInputWarning())
```

In [6]:

```
# a = userid, p = itemid, data = whole data set,
# sim = similarity matrix t = similarity threshold
def 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
    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
```

Average aggregation method

In [7]:

```
# g = groud of users (list of usedids), i = itemid, data = whole dataset
def average_aggregation(g, i, data):
    # ratings for item i, given by users in the group
    ratings = []

    # obtaing ratings, either from data or predict it
    for user in g:
        rating = data[user-1][i-1]
        if rating == None:
            rating = predict(user, i, data, sim_matrix, 10)
        ratings.append(rating)

    return np.average(ratings)
```

Top 20 recommendations for a group of 3 users

In [8]:

```
g = [1, 11, 111]
# dict for group ratings for all items (key=itemid, value=group rating for item)
ratings = {}

for i in itemids:
    ratings[i] = average_aggregation(g, i, data)

# sort dict so that highly rated items for the group are first
ratings = dict(sorted(ratings.items(), key=lambda x: x[1], reverse=True))

recommendations = dict(list(ratings.items())[:20])
df = pd.DataFrame(list(zip(list(recommendations.keys()), list(recommendations.values()))
print(df)
```

```
    itemid    rating
0      258  4.666667
1        9  4.513889
2       15  4.513889
3      173  4.513889
4      196  4.513889
5      268  4.513889
6      269  4.488029
7      286  4.203431
8       28  4.180556
9       86  4.180556
10     100  4.180556
11     111  4.180556
12     191  4.180556
13     208  4.180556
14     242  4.154696
15     277  4.050654
16     318  4.050654
17     332  4.050654
18     357  4.050654
19     423  4.050654
```

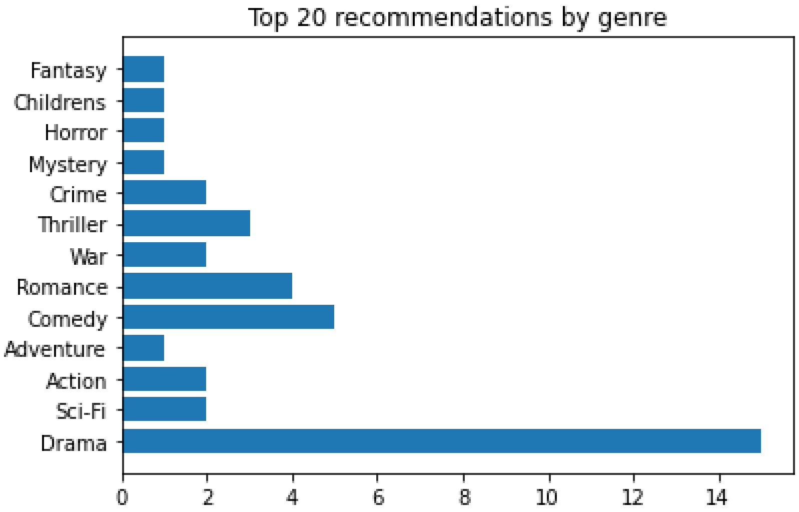
In [67]:

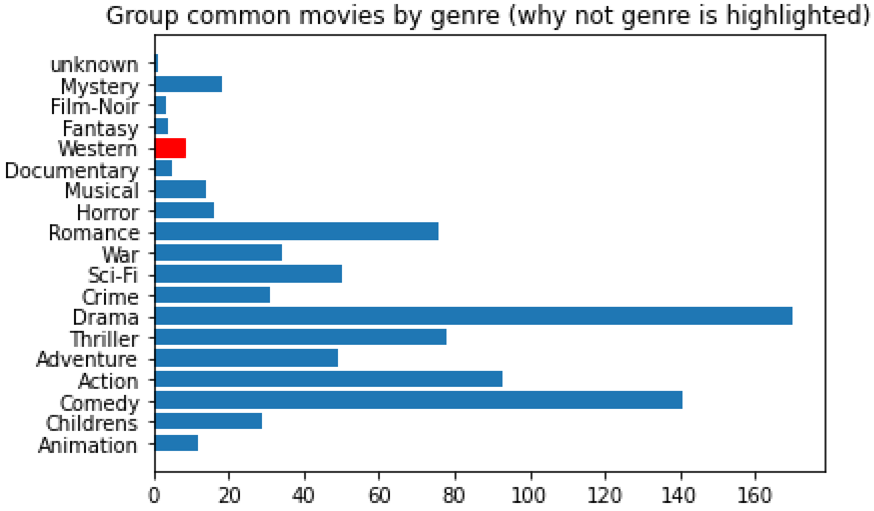
```python
# itemid = why not this item, r = ratings for all items for the group, g = group userid
def granularity_case_atomic(itemid, r, g, data):
    # check if item does not exist in data
    if itemid not in itemids:
        print('Item does not exist')
        return

    # groups rating for the item in question
    rating = r[itemid]

    # ratings in list format (needed to get indeces)
    ratings_list = list(ratings.items())

    # placing on the group ratings (best = 1)
    index = list(ratings.keys()).index(itemid) + 1

    # check if item was actually recommended
    if index <= 20:
        print('Item WAS recommended')
        return

    # check tie break
    if rating == ratings_list[19][1]:
        print('Tie break (when sorting python dicts, if ratings are same, lowest item i

    # check if item would have been recommended if user asked for more items
    # threshold for this case = 20
    if index <= 40:
        print('User asked for too few items')


print('Test item that does not exits:')
granularity_case_atomic(5321321, ratings, g, data)

print('Test two different items:')
granularity_case_atomic(9, ratings, g, data)
granularity_case_atomic(429, ratings, g, data)
```

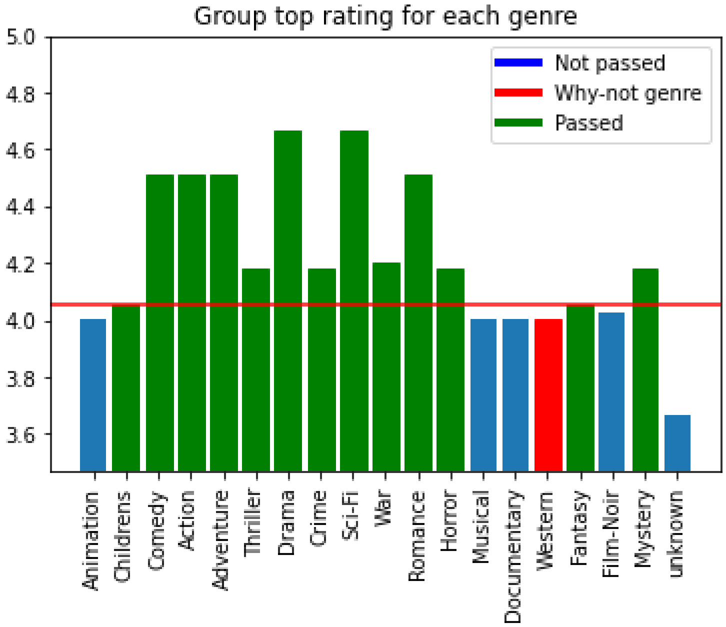
```
Test item that does not exits:
Item does not exist
Test two different items:
Item WAS recommended
Tie break (when sorting python dicts, if ratings are same, lowest item id will be sorted
as first)
User asked for too few items
```

In [75]:

```python
# why_not_genre = why was this genre not recommended, g = group of users, r = top 20 re
def granularity_case_group(why_not_genre, r, g, data):
    # ratings in list format (needed to get indeces)
    ratings_list = list(ratings.items())
    recommendations_histogram, genre_rating_avg_all, genre_rating_avg, genre_rating_max

    # top 20 recommendation genre histogram
    plt.barh(list(recommendations_histogram.keys()), recommendations_histogram.values()
    plt.title('Top 20 recommendations by genre')
    plt.show()


    # Groups common movies genre histogram
    genre_index = list(genre_histogram.keys()).index(why_not_genre)
    barlist = plt.barh(list(genre_histogram.keys()), genre_histogram.values())
    barlist[genre_index].set_color('r')
    plt.title('Group common movies by genre (why not genre is highlighted)')
    plt.show()


    # Group top rating for each genre
    genre_index = list(genre_rating_max.keys()).index(why_not_genre)
    genre_max = plt.bar(list(genre_rating_max.keys()), genre_rating_max.values())
    genre_max[genre_index].set_color('r')

    for genre in recommendations_histogram:
        index = list(genre_rating_max.keys()).index(genre)
        genre_max[index].set_color('g')

    plt.axhline(y=ratings_list[19][1], color='r', linestyle='-')
    ax = plt.gca()
    ax.set_ylim([min(list(genre_rating_max.values()))-0.2, 5])
    custom_lines = [Line2D([0], [0], color='b', lw=4),
                    Line2D([0], [0], color='r', lw=4),
                    Line2D([0], [0], color='g', lw=4)]

    ax.legend(custom_lines, ['Not passed', 'Why-not genre', 'Passed'])
    plt.xticks(rotation=90)
    plt.title('Group top rating for each genre')
    plt.show()

    # probability that the why-not genre appears in top 20
    why_not_genre_movies = genre_histogram[why_not_genre]
    prob = 1 - (math.comb(seen_movies - why_not_genre_movies, 20) / math.comb(seen_movi


    print('Probability that genre', why_not_genre, 'appears in the groups top 20 (assum
    print(np.round(prob * 100, 3),  '%')

granularity_case_group('Western', ratings, g, data)
```







```
Probability that genre Western appears in the groups top 20 (assuming that the group on
average likes all genres equally):
33.905 %
```

In [18]:

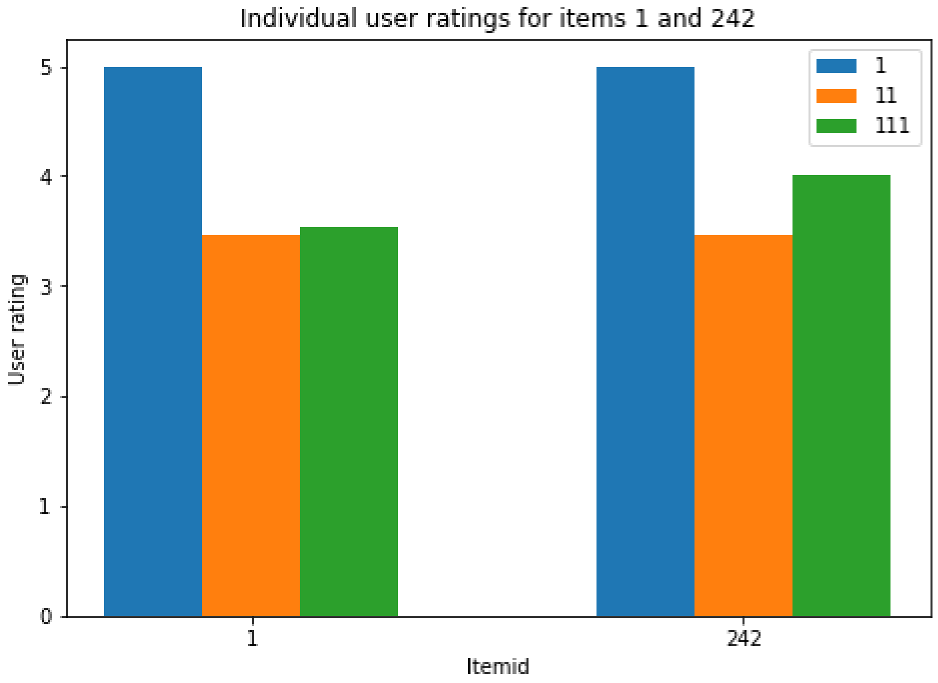
```python
# get genre data for the groups recommended movies and seen movies
def group_genre_data(g, r, data):
```

```python
# top 20 recommendations histogram
recommendations_histogram = {}

# ratings in list format (needed to get indeces)
ratings_list = list(ratings.items())

for movie in ratings_list[:20]:
    for genre in movies[movie[0]-1].genres:
        if genre not in recommendations_histogram:
            recommendations_histogram[genre] = 1
        else:
            recommendations_histogram[genre] = recommendations_histogram[genre] + 1

# group average ratings for all movies
genre_rating_avg_all = {}
for movie in ratings_list:
    for genre in movies[movie[0]-1].genres:
        if genre not in genre_rating_avg_all:
            genre_rating_avg_all[genre] = [movie[1]]
        else:
            tmp_genre_ratings = genre_rating_avg_all[genre]
            tmp_genre_ratings.append(movie[1])
            genre_rating_avg_all[genre] = tmp_genre_ratings

for genre in genre_rating_avg_all:
    genre_rating_avg_all[genre] = np.average(genre_rating_avg_all[genre])


# see what genres the users in the group have watched and ratings for movies in tho
genre_ratings = {}
genre_histogram = {}
seen_movies = []
for user in g:
    for itemid in itemids:
        rating = data[user-1][itemid-1]
        if rating != None:
            if itemid not in seen_movies:
                for genre in movies[itemid-1].genres:
                    if genre not in genre_histogram:
                        genre_histogram[genre] = 1
                    else:
                        genre_histogram[genre] = genre_histogram[genre] + 1

                    if genre not in genre_ratings:
                        genre_ratings[genre] = [r[itemid]]
                    else:
                        tmp_genre_ratings = genre_ratings[genre]
                        tmp_genre_ratings.append(r[itemid])
                        genre_ratings[genre] = tmp_genre_ratings

                # keep track the movies that have already been taken into account i
                seen_movies.append(itemid)

genre_rating_avg = {}
genre_rating_max = {}

for genre in genre_ratings:
    genre_rating_avg[genre] = np.average(genre_ratings[genre])
    genre_rating_max[genre] = max(genre_ratings[genre])
    return recommendations_histogram, genre_rating_avg_all, genre_rating_avg, genre_rat
```

In [76]:

```
# i = itemid, pos = wanted position for item i, g = group of users, r = top 20 recommen
def position_absenteeism(i, pos, g, r, data):
    if pos > len(r):
        print('Position out of bounds')
        return

    # groups rating for item i
    i_rating = r[i]

    # group ratings for all items in list format
    r = list(r.items())

    # item in the asked position (id, rating)
    (j, j_rating) = r[pos-1]

    # position of item i
    i_pos = r.index((i, i_rating)) + 1

    # check if item i was ranked higher than pos
    if i_pos <= pos:
        print('Item', i, 'at position', i_pos, 'was ranked higher or equal to position'
        return

    # Compare item ratings
    print('Item', i, 'at position', i_pos, 'was rated', np.round(i_rating,3), 'while it

    # get groups ratings for item i and j
    i_ratings = []
    j_ratings = []

    for user in g:
        i_r = data[user-1][i-1]
        j_r = data[user-1][j-1]
        if i_r== None:
            i_r = predict(user, i, data, sim_matrix, 10)

        if j_r== None:
            j_r = predict(user, i, data, sim_matrix, 10)

        i_ratings.append(i_r)
        j_ratings.append(j_r)


    fig = plt.figure()
    X = np.arange(1,3)
    user_ratings = np.transpose(np.stack((i_ratings, j_ratings)))

    ax = fig.add_axes([0,0,1,1])
    shift = 0
    for rating in user_ratings:
        bar = ax.bar(X + shift, rating, width = 0.2)
        shift += 0.2

    plt.xticks(ticks=X+0.2, labels=[i, j])
    plt.xlabel('Itemid')
    plt.ylabel('User rating')
    s = 'Individual user ratings for items ' + str(i) + ' and ' + str(j)
    plt.title(s)
    ax.legend(labels= g)
    plt.show()
    print(i_ratings, j_ratings)

position_absenteeism(1, 15, g, ratings, data)
```

```
Item 1 at position 34 was rated 4.002 while item at postion 15 was rated 4.155
```



```
[5, 3.4640883977900554, 3.5416666666666665] [5, 3.4640883977900554, 4]
```