KMeans Clustering of Netflix Movie Data for CSCI6370 Dr. Lei HanSheng

Project Leader: Steven Bowler UTRGV 20562494 Project Git Repo: Netflix Study (https://github.com/stevenbowler/netflixstudy)

Go to very bottom of file for heatmap of clusters for 0s and 1s as per homework assignment

Current State of Analysis: The full dataframe/matrix df_p is loaded here but due to its size, 144380 x 5334, KMeans clustering took 24+ hours and did not finish; therefore, to prove out the KMeans below, used df_p_short which just has the first 1,000 rows of df_p. Then for display of the 5 clusters at the bottom of this file, used heatmaps of 70 users x 50 movies.

Next steps: Evaluating cloud options: Google, AWS, Azure; to acquire necessary processing and memory to handle the full dataset.

Attribution: Used helper function to display heat map from here (https://programming.rhysshea.com/K-means_movie_ratings/)

Next Steps: Evaluating use of collaborative filtering to create recommender table, something like this (https://github.com/anjanatiha/Movie-Recommendation-Engine-using-User-Based-Collaborative-Filtering)

Need to fire up Jupyter with this to be able to load df_p with its almost 700MM nodes:

jupyter notebook --NotbookApp.iopub_Data_Rate_Limit=1e10

In [1]:

```python
# Import necessary modules
import pandas as pd
import numpy as np
from pandas_profiling import ProfileReport
import matplotlib.pyplot as plt
from matplotlib import style
style.use('ggplot')
from sklearn.cluster import KMeans
from scipy.sparse import csr_matrix
```

In [2]:

```python
df_p = pd.read_csv('../data/processed/df_p.csv')  # this was created in netflixstudySecondaryEVA.ipynb
```

In [6]:

```python
df_p_short = df_p.head(1000)
```

In [7]:
```
df_p_short
```

Out[7]:

	Cust_Id	3	8	16	17	18	26	28	30	33	...	17741	17743	17751	17
0	6	NaN	NaN	NaN	NaN	NaN	NaN	NaN	3.0	NaN	...	NaN	NaN	NaN	N
1	7	NaN	5.0	NaN	NaN	NaN	NaN	4.0	5.0	NaN	...	NaN	NaN	NaN	N
2	10	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN	N
3	79	NaN	NaN	NaN	NaN	NaN	NaN	NaN	3.0	NaN	...	NaN	NaN	NaN	N
4	97	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN	N
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
995	18426	NaN	NaN	NaN	NaN	1.0	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN	N
996	18432	NaN	NaN	NaN	NaN	NaN	NaN	NaN	4.0	NaN	...	NaN	NaN	4.0	N
997	18475	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN	N
998	18517	NaN	NaN	NaN	NaN	NaN	NaN	3.0	NaN	NaN	...	NaN	NaN	NaN	N
999	18527	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	NaN	...	NaN	NaN	NaN	N

1000 rows × 5333 columns

In [8]:
```
# create sparse array for load to KMeans, won't run with np.NaN
# sparse_ratings = csr_matrix(pd.DataFrame(df_p).sparse.to_coo())
sparse_ratings = csr_matrix(df_p_short.values)
```

In [9]:
```
sparse_ratings.shape
```

Out[9]:
```
(1000, 5333)
```

In [10]:
```
# convert to int to stop crashing in KMeans, convert sparse array from float64
to int, also due to KMeans memory overflow
#   with float64
sparse_ratings_int = sparse_ratings.astype(int)
```

In [11]:
```
predictions = KMeans(n_clusters=5, algorithm='full').fit_predict(sparse_rating
s_int)
```

In [121]:

```
# %load ../src/features/rating_helper.py
# %load ../src/features/rating_helper.py
import matplotlib.pyplot as plt
import pandas as pd
import numpy as np
from mpl_toolkits.axes_grid1 import make_axes_locatable
from sklearn.cluster import KMeans
from sklearn.metrics import mean_squared_error
import itertools
from sklearn.metrics import silhouette_samples, silhouette_score


def draw_scatterplot(x_data, x_label, y_data, y_label):
    fig = plt.figure(figsize=(8, 8))
    ax = fig.add_subplot(111)

    plt.xlim(0, 5)
    plt.ylim(0, 5)
    ax.set_xlabel(x_label)
    ax.set_ylabel(y_label)
    ax.scatter(x_data, y_data, s=30)

# plots clusters (with colour) based on the predictions made using the fit_pre
dict method


def draw_clusters(biased_dataset, predictions, cmap='viridis'):
    fig = plt.figure(figsize=(8, 8))
    ax = fig.add_subplot(111)
    plt.xlim(0, 5)
    plt.ylim(0, 5)
    ax.set_xlabel('Avg scifi rating')
    ax.set_ylabel('Avg romance rating')

    clustered = pd.concat([biased_dataset.reset_index(),
                           pd.DataFrame({'group': predictions})], axis=1)
    plt.scatter(clustered['avg_scifi_rating'],
                clustered['avg_romance_rating'], c=clustered['group'], s=20, c
map=cmap)


def clustering_errors(k, data):
    kmeans = KMeans(n_clusters=k).fit(data)
    predictions = kmeans.predict(data)
    #cluster_centers = kmeans.cluster_centers_
    # errors = [mean_squared_error(row, cluster_centers[cluster]) for row, clu
ster in zip(data.values, predictions)]
    # return sum(errors)
    silhouette_avg = silhouette_score(data, predictions)
    return silhouette_avg


def sparse_clustering_errors(k, data):
    kmeans = KMeans(n_clusters=k).fit(data)
    predictions = kmeans.predict(data)
    cluster_centers = kmeans.cluster_centers_
    errors = [mean_squared_error(row, cluster_centers[cluster])
              for row, cluster in zip(data, predictions)]
    return sum(errors)


def get_genre_ratings(ratings, movies, genres, column_names):
    genre_ratings = pd.DataFrame()
    for genre in genres:
        genre_movies = movies[movies['genres'].str.contains(genre)]
        avg_genre_votes_per_user = ratings[ratings['movieId'].isin(genre_movie
s['movieId'])].loc[:, [
            'userId', 'rating']].groupby(['userId'])['rating'].mean().round(2)

        genre_ratings = pd.concat(
            [genre_ratings, avg_genre_votes_per_user], axis=1)

    genre_ratings.columns = column_names
    return genre_ratings


def get_dataset_3(movies, ratings, genre_ratings):
    # Extract action ratings from dataset
    action_movies = movies[movies['genres'].str.contains('Action')]
    # Get average vote on action movies per user
    avg_action_votes_per_user = ratings[ratings['movieId'].isin(action_movies[
'movieId'])].loc[:, [
        'userId', 'rating']].groupby(['userId'])['rating'].mean().round(2)
    # Add action ratings to romance and scifi in dataframe
    genre_ratings_3 = pd.concat(
        [genre_ratings, avg_action_votes_per_user], axis=1)
    genre_ratings_3.columns = ['avg_romance_rating',
                               'avg_scifi_rating', 'avg_action_rating']

    # Let's bias the dataset a little so our clusters can separate scifi vs ro
mance more easily
    b1 = 3.2
    b2 = 2.5
    biased_dataset_3 = genre_ratings_3[((genre_ratings_3['avg_romance_rating']
< b1 - 0.2) & (genre_ratings_3['avg_scifi_rating'] > b2)) | (
        (genre_ratings_3['avg_scifi_rating'] < b1) & (genre_ratings_3['avg_rom
ance_rating'] > b2))]
    biased_dataset_3 = pd.concat([biased_dataset_3[:300], genre_ratings_3[:2
]])
    biased_dataset_3 = pd.DataFrame(biased_dataset_3.to_records())

    return biased_dataset_3


def draw_clusters_3d(biased_dataset_3, predictions):
    fig = plt.figure(figsize=(8, 8))
    ax = fig.add_subplot(111)

    plt.xlim(0, 5)
    plt.ylim(0, 5)
    ax.set_xlabel('Avg scifi rating')
    ax.set_ylabel('Avg romance rating')
    clustered = pd.concat(
        [biased_dataset_3.reset_index(), pd.DataFrame({'group': predictions
})], axis=1)

    colors = itertools.cycle(plt.rcParams["axes.prop_cycle"].by_key()["color"
])

    for g in clustered.group.unique():
        color = next(colors)
        for index, point in clustered[clustered.group == g].iterrows():
            if point['avg_action_rating'].astype(float) > 3:
                size = 50
            else:
                size = 15
            plt.scatter(point['avg_scifi_rating'],
                        point['avg_romance_rating'],
                        s=size,
                        color=color)


def draw_movie_clusters(clustered, max_users, max_movies):
    c = 1
    for cluster_id in clustered.group.unique():
        # To improve visibility, we're showing at most max_users users and max
_movies movies per cluster.
        # You can change these values to see more users & movies per cluster
        d = clustered[clustered.group == cluster_id].drop(
            ['Cust_Id', 'group'], axis=1)
        n_users_in_cluster = d.shape[0]

        d = sort_by_rating_density(d, max_movies, max_users)

#          d = d.reindex_axis(d.mean().sort_values(ascending=False).index, axis
=1)   # commented out by SB 20oct2020
#          d = d.reindex_axis(d.count(axis=1).sort_values(ascending=False).inde
x)
        d = d.iloc[:max_users, :max_movies]
        n_users_in_plot = d.shape[0]

        # We're only selecting to show clusters that have more than 9 users, o
therwise, they're less interesting
        if len(d) > 9:
            print('cluster # {}'.format(cluster_id))
            print('# of users in cluster: {}.'.format(n_users_in_cluster),
                  '# of users in plot: {}'.format(n_users_in_plot))
            fig = plt.figure(figsize=(15, 4))
            ax = plt.gca()

            ax.invert_yaxis()
            ax.xaxis.tick_top()
            labels = d.columns.str[:40]

            ax.set_yticks(np.arange(d.shape[0]), minor=False)
            ax.set_xticks(np.arange(d.shape[1]), minor=False)

            ax.set_xticklabels(labels, minor=False)
            ax.get_yaxis().set_visible(False)

            # Heatmap
            heatmap = plt.imshow(d, vmin=0, vmax=5, aspect='auto')

            ax.set_xlabel('movies')
            ax.set_ylabel('User id')

            divider = make_axes_locatable(ax)
            cax = divider.append_axes("right", size="5%", pad=0.05)

            # Color bar
            cbar = fig.colorbar(heatmap, ticks=[5, 4, 3, 2, 1, 0], cax=cax)
            cbar.ax.set_yticklabels(
                ['5 stars', '4 stars', '3 stars', '2 stars', '1 stars', '0 stars'])

            plt.setp(ax.get_xticklabels(), rotation=90, fontsize=9)
            plt.tick_params(axis='both', which='both', bottom='off',
                            top='off', left='off', labelbottom='off', labelleft='off')
            # print('cluster # {} \n(Showing at most {} users and {} movies)'.format(cluster_id, max_users, max_movies))

            plt.show()

            # Let's only show 5 clusters
            # Remove the next three lines if you want to see all the clusters
            # Contribution welcomed: Pythonic way of achieving this
            # c = c+1
            # if c > 6:
            #    break


def get_most_rated_movies(user_movie_ratings, max_number_of_movies):
    # 1- Count
    user_movie_ratings = user_movie_ratings.append(
        user_movie_ratings.count(), ignore_index=True)
    # 2- sort
    user_movie_ratings_sorted = user_movie_ratings.sort_values(
        len(user_movie_ratings)-1, axis=1, ascending=False)
    user_movie_ratings_sorted = user_movie_ratings_sorted.drop(
        user_movie_ratings_sorted.tail(1).index)
    # 3- slice
    most_rated_movies = user_movie_ratings_sorted.iloc[:,
                                                       :max_number_of_movies]
    return most_rated_movies


def get_users_who_rate_the_most(most_rated_movies, max_number_of_movies):
    # Get most voting users
    # 1- Count
    most_rated_movies['counts'] = pd.Series(most_rated_movies.count(axis=1))
    # 2- Sort
    most_rated_movies_users = most_rated_movies.sort_values(
        'counts', ascending=False)
    # 3- Slice
    most_rated_movies_users_selection = most_rated_movies_users.iloc[:max_numb
er_of_movies, :]
    most_rated_movies_users_selection = most_rated_movies_users_selection.drop
([

'counts'], axis=1)

    return most_rated_movies_users_selection


def sort_by_rating_density(user_movie_ratings, n_movies, n_users):
    most_rated_movies = get_most_rated_movies(user_movie_ratings, n_movies)
    most_rated_movies = get_users_who_rate_the_most(most_rated_movies, n_users
)
    return most_rated_movies


def draw_movies_heatmap(most_rated_movies_users_selection, axis_labels=True):

    # Reverse to match the order of the printed dataframe
    #most_rated_movies_users_selection = most_rated_movies_users_selection.ilo
c[::-1]

    fig = plt.figure(figsize=(15, 4))
    ax = plt.gca()

    # Draw heatmap
    heatmap = ax.imshow(most_rated_movies_users_selection,
                        interpolation='nearest', vmin=0, vmax=5, aspect='auto'
)

    if axis_labels:
        ax.set_yticks(
            np.arange(most_rated_movies_users_selection.shape[0]), minor=False
)
        ax.set_xticks(
            np.arange(most_rated_movies_users_selection.shape[1]), minor=False
)
        ax.invert_yaxis()
        ax.xaxis.tick_top()
        labels = most_rated_movies_users_selection.columns.str[:40]
        ax.set_xticklabels(labels, minor=False)
        ax.set_yticklabels(
            most_rated_movies_users_selection.index, minor=False)
        plt.setp(ax.get_xticklabels(), rotation=90)
    else:
        ax.get_xaxis().set_visible(False)
        ax.get_yaxis().set_visible(False)

    ax.grid(False)
    ax.set_ylabel('User id')

    # Separate heatmap from color bar
    divider = make_axes_locatable(ax)
    cax = divider.append_axes("right", size="5%", pad=0.05)

    # Color bar
    cbar = fig.colorbar(heatmap, ticks=[5, 4, 3, 2, 1, 0], cax=cax)
    cbar.ax.set_yticklabels(
        ['5 stars', '4 stars', '3 stars', '2 stars', '1 stars', '0 stars'])

    plt.show()

    # breaks the data up so we don't have both genres highly rates, more like
 one or the other


def bias_genre_rating_dataset(genre_ratings, score_limit_1, score_limit_2):
    biased_dataset = genre_ratings[((genre_ratings['avg_romance_rating'] < sco
re_limit_1 - 0.2) & (genre_ratings['avg_scifi_rating'] > score_limit_2))
                                   | ((genre_ratings['avg_scifi_rating'] < sco
re_limit_1) & (genre_ratings['avg_romance_rating'] > score_limit_2))]
    biased_dataset = pd.concat([biased_dataset[:300], genre_ratings[:2]])
    biased_dataset = pd.DataFrame(biased_dataset.to_records())
    return biased_dataset
```

In [114]:

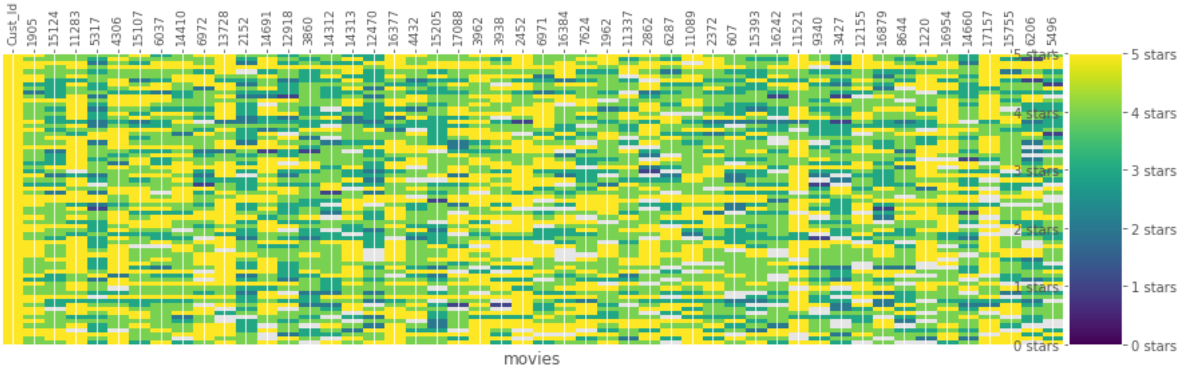
```
import recommendation_helper2   #  this works when recommendation_helper2.py i
s in this directory, don't need %load above
```

In [43]:

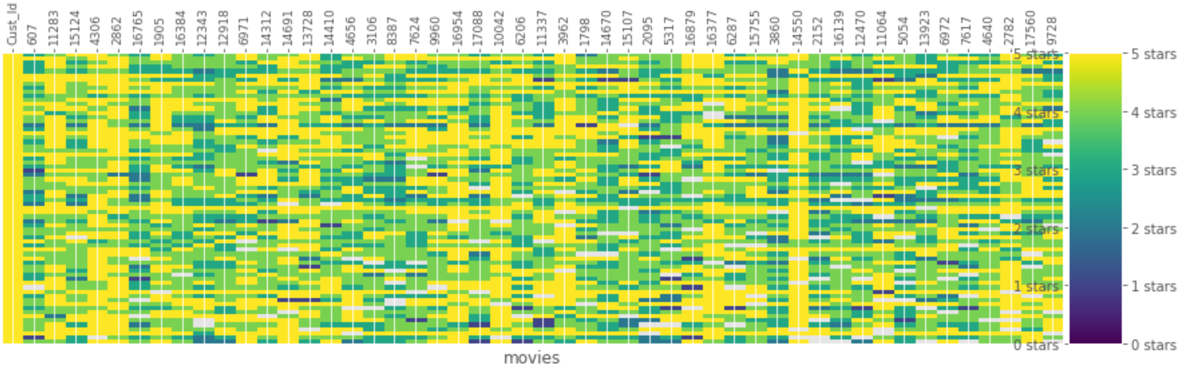
```
max_users = 70
max_movies = 50

# not sure use df_p or sparse_ratings
clustered = pd.concat([df_p_short.reset_index(), pd.DataFrame({'group':predictions})], axis=1)
# helper.draw_movie_clusters(clustered, max_users, max_movies)
draw_movie_clusters(clustered, max_users, max_movies)
```

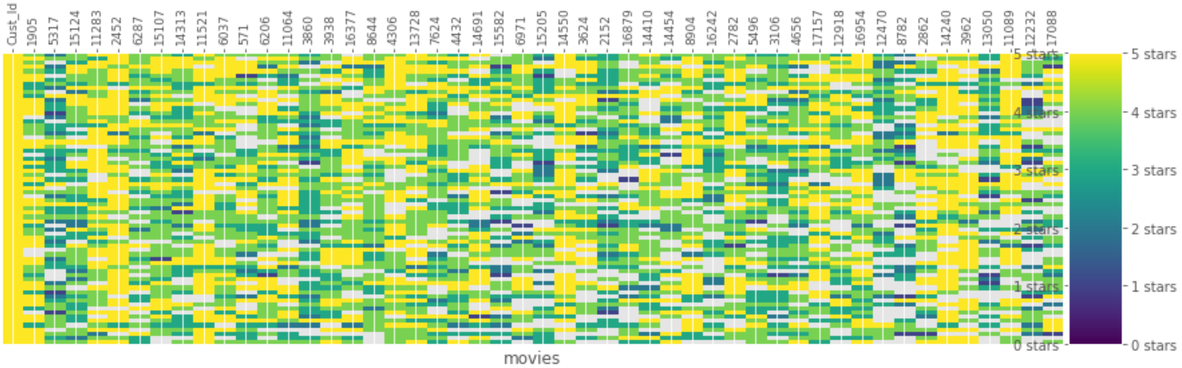
```
cluster # 3
# of users in cluster: 208. # of users in plot: 70
```



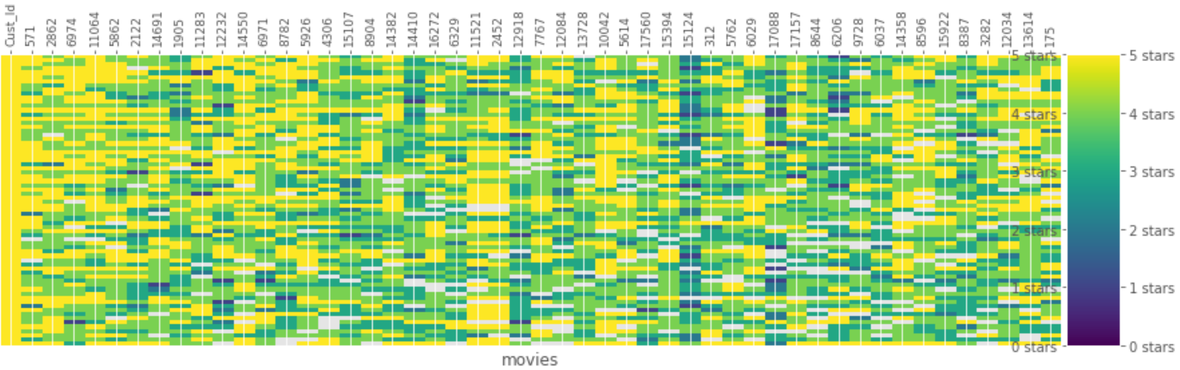
```
cluster # 2
# of users in cluster: 89. # of users in plot: 70
```



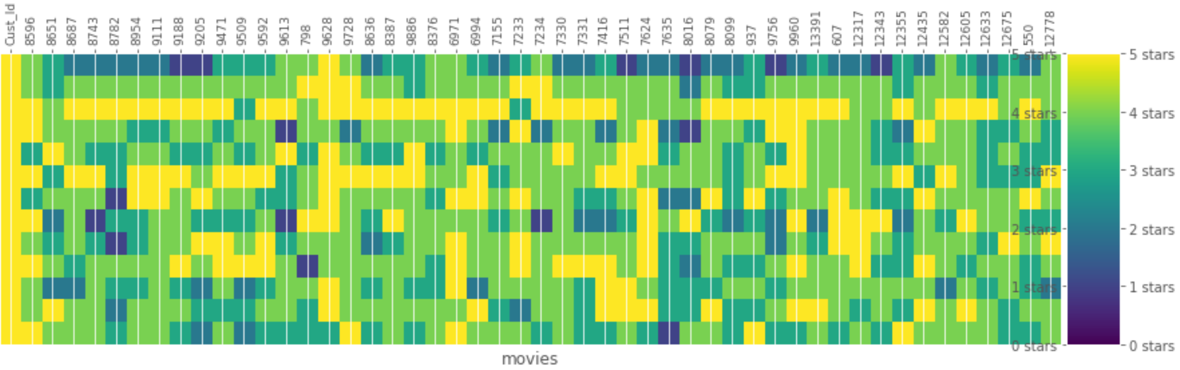
```
cluster # 1
# of users in cluster: 544. # of users in plot: 70
```



```
cluster # 0
# of users in cluster: 146. # of users in plot: 70
```



```
cluster # 4
# of users in cluster: 13. # of users in plot: 13
```



Also, per Homework #2 assignment restructure dataset to 0s and 1s for scatter plot and cluster

In [56]:
```
# create array of 0 and 1 for scatter plot
array_df_p_not_nan = np.invert(np.isnan(df_p.values))
```

In [57]:
```
# this is the matrix of 0s and 1s called out in the assignment, will now manip
ulate
array_df_p_not_nan
```

Out[57]:
```
array([[ True, False, False, ..., False, False, False],
       [ True, False,  True, ..., False,  True, False],
       [ True, False, False, ..., False, False, False],
       ...,
       [ True, False, False, ..., False,  True, False],
       [ True, False, False, ..., False, False, False],
       [ True, False, False, ..., False, False, False]])
```

In [89]:
```
# create array w dimensions of df_p where if np.NaN then False, else if !np.Na
N then True
count_nan = np.invert(np.isnan(df_p.values))
```

In [90]:
```
count_nan
```

Out[90]:
```
array([[ True, False, False, ..., False, False, False],
       [ True, False,  True, ..., False,  True, False],
       [ True, False, False, ..., False, False, False],
       ...,
       [ True, False, False, ..., False,  True, False],
       [ True, False, False, ..., False, False, False],
       [ True, False, False, ..., False, False, False]])
```

In [91]:
```
# create dataframe with boolean matrix
df_p_not_nan = pd.DataFrame(count_nan)
```

In [92]:
```
# add Cust_Id as index
df_p_not_nan.set_index(df_p["Cust_Id"], inplace=True)
```

In [93]:
```
df_p_not_nan
```

Out[93]:

	0	1	2	3	4	5	6	7	8	9	...	5323	5324	53
Cust_Id														
6	True	False	False	False	False	False	False	False	True	False	...	False	False	Fal
7	True	False	True	False	False	False	False	True	True	False	...	False	False	Fal
10	True	False	False	False	False	False	False	False	False	False	...	False	False	Fal
79	True	False	False	False	False	False	False	False	True	False	...	False	False	Fal
97	True	False	False	False	False	False	False	False	False	False	...	False	False	Fal
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
2649370	True	False	False	False	False	False	False	False	False	False	...	False	False	Fal
2649378	True	False	False	False	False	False	False	True	True	False	...	False	False	Fal
2649388	True	False	False	False	False	False	False	False	True	False	...	False	False	Fal
2649426	True	False	False	False	True	False	False	True	True	False	...	False	False	Fal
2649429	True	False	False	False	False	False	False	False	True	False	...	False	False	Fal

144380 rows × 5333 columns

In [94]:
```
df_p.columns
```

Out[94]:
```
Index(['Cust_Id', '3', '8', '16', '17', '18', '26', '28', '30', '33',
       ...
       '17741', '17743', '17751', '17756', '17758', '17761', '17762', '1776
3',
       '17764', '17769'],
      dtype='object', length=5333)
```

In [95]:
```
# set columns same as original df_p
df_p_not_nan.columns = df_p.columns
```

In [96]:
```
df_p_not_nan
```

Out[96]:

	Cust_Id	3	8	16	17	18	26	28	30	33	...	17741	17743
Cust_Id													
6	True	False	False	False	False	False	False	False	True	False	...	False	False
7	True	False	True	False	False	False	False	True	True	False	...	False	False
10	True	False	False	False	False	False	False	False	False	False	...	False	False
79	True	False	False	False	False	False	False	False	True	False	...	False	False
97	True	False	False	False	False	False	False	False	False	False	...	False	False
...	...	...	...	...	...	...	...	...	...	...	...	...	...
2649370	True	False	False	False	False	False	False	False	False	False	...	False	False
2649378	True	False	False	False	False	False	False	True	True	False	...	False	False
2649388	True	False	False	False	False	False	False	False	True	False	...	False	False
2649426	True	False	False	False	True	False	False	True	True	False	...	False	False
2649429	True	False	False	False	False	False	False	False	True	False	...	False	False

144380 rows × 5333 columns

In [104]:
```
# drop Cust_Id column
df_p_not_nan.drop('Cust_Id',axis=1, inplace=True)
```

In [105]:
```
# convert boolean to int
df_p_not_nan_int = df_p_not_nan.astype(int)
```

```
In [106]: # dataframe per homework request for KMeans clustering where 1 = Movie_Id was
           rated by this Cust_Id
          df_p_not_nan_int
```

```
Out[106]:
                  3  8  16  17  18  26  28  30  33  44  ...  17741  17743  17751  17756  17758  17761
          Cust_Id
                6 0  0   0   0   0   0   0   1   0   0  ...      0      0      0      0      0      0
                7 0  1   0   0   0   0   1   1   0   0  ...      0      0      0      0      0      0
               10 0  0   0   0   0   0   0   0   0   0  ...      0      0      0      0      0      0
               79 0  0   0   0   0   0   0   1   0   0  ...      0      0      0      0      0      0
               97 0  0   0   0   0   0   0   0   0   0  ...      0      0      0      0      0      0
              ... ...... ... ... ... ... ... ... ... ...  ...    ...    ...    ...    ...    ...    ...
          2649370 0  0   0   0   0   0   0   0   0   0  ...      0      0      0      0      0      0
          2649378 0  0   0   0   0   0   1   1   0   0  ...      0      0      0      0      0      0
          2649388 0  0   0   0   0   0   0   1   0   0  ...      0      0      0      0      0      0
          2649426 0  0   0   1   0   0   1   1   0   0  ...      0      0      0      0      0      0
          2649429 0  0   0   0   0   0   0   1   0   0  ...      0      0      0      0      0      0

          144380 rows × 5332 columns
```

```
In [111]: # again due to size of dataset, use first 1000 rows, then run full dataset up
           on cloud with extra CPUs and Memory
          df_p_short2 = df_p_not_nan_int.head(1000)
```

homework 2 map clusters with only 0s and 1s (even though heatmap shows up to 5 stars, only 2

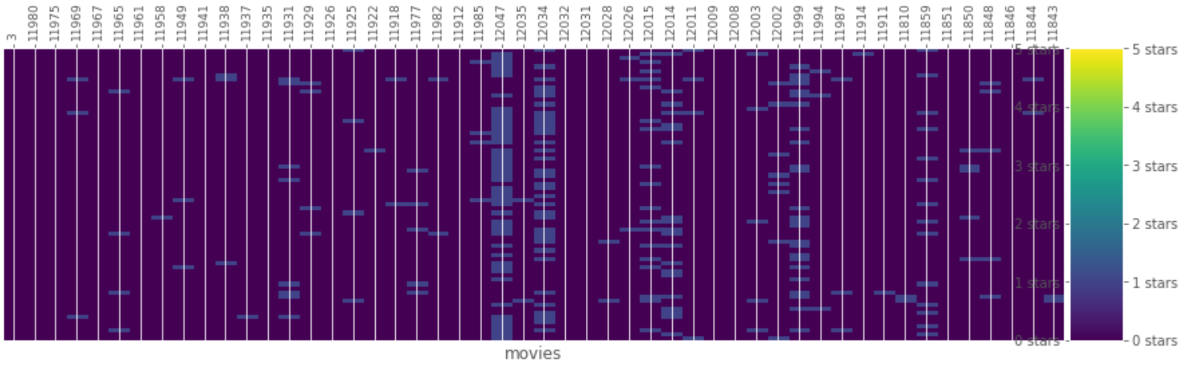
```
In [112]: predictions2 = KMeans(n_clusters=5, algorithm='full').fit_predict(df_p_short2)
```

In [122]:

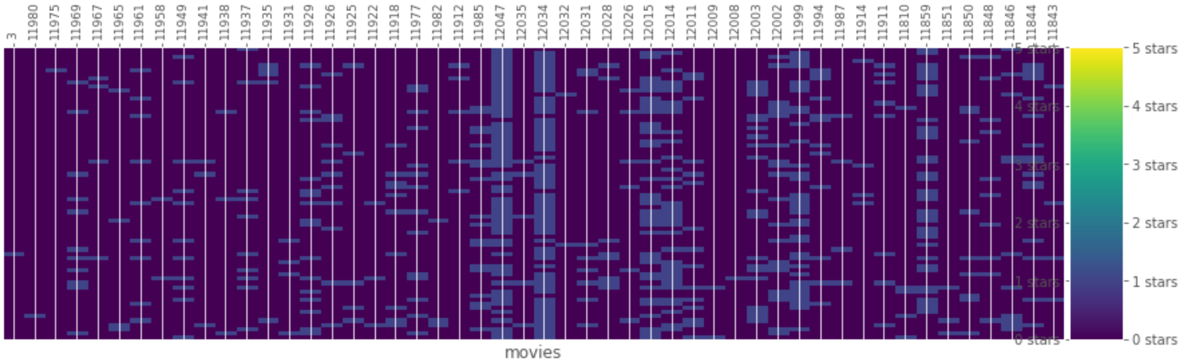
```
#  same as with ratings, show cluster heatmaps for 70 users and 50 movies
max_users = 70
max_movies = 50

# not sure use df_p or sparse_ratings
clustered = pd.concat([df_p_short2.reset_index(), pd.DataFrame({'group':predic
tions2})], axis=1)
# helper.draw_movie_clusters(clustered, max_users, max_movies)
draw_movie_clusters(clustered, max_users, max_movies)
```

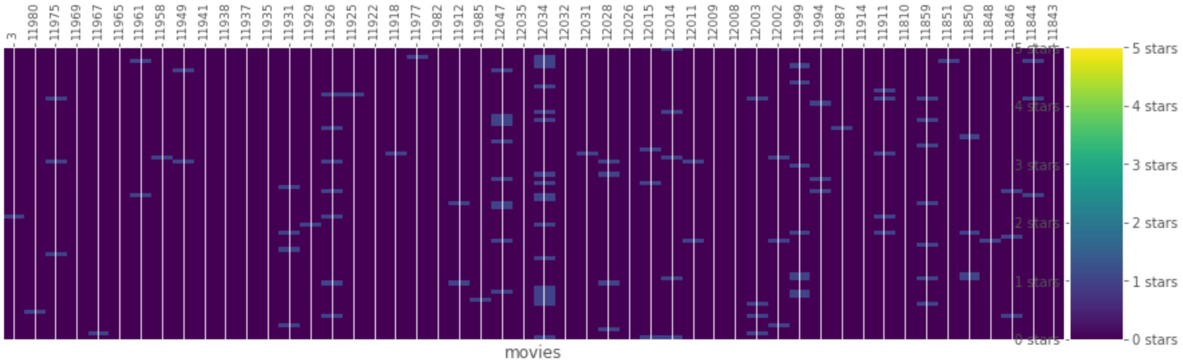
```
cluster # 1
# of users in cluster: 222. # of users in plot: 70
```



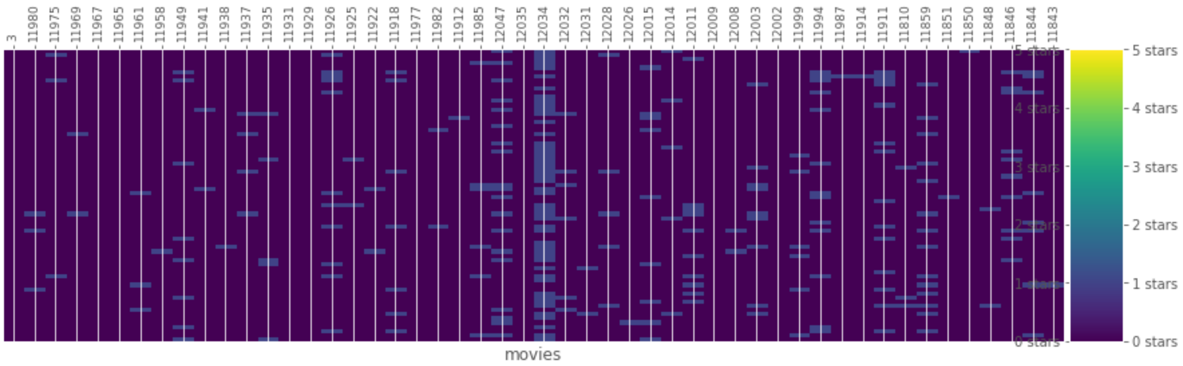
```
cluster # 2
# of users in cluster: 102. # of users in plot: 70
```



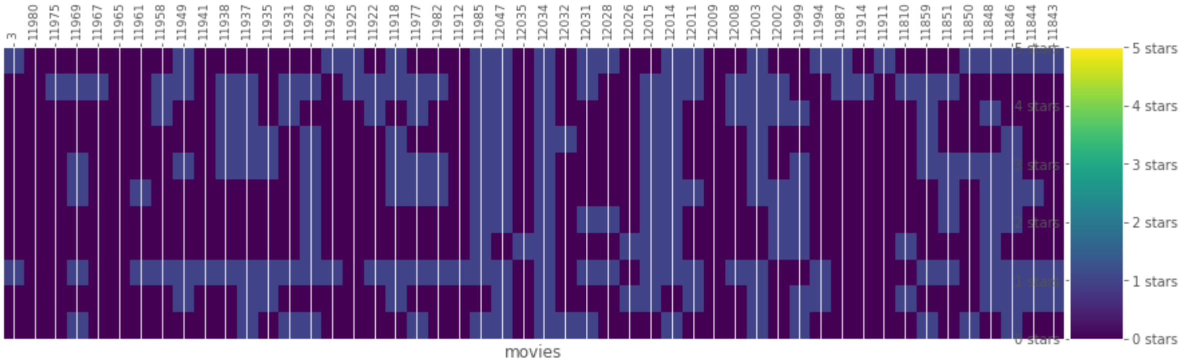
```
cluster # 3
# of users in cluster: 520. # of users in plot: 70
```



```
cluster # 0
# of users in cluster: 145. # of users in plot: 70
```



```
cluster # 4
# of users in cluster: 11. # of users in plot: 11
```


5 stars
4 stars
3 stars
2 stars
1 stars
0 stars
movies
5 stars
4 stars
3 stars
2 stars
1 stars
0 stars