nmf-implementation

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1 Fundamentals of Machine Learning - Exercise 9

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```
In [1]: import math
        import matplotlib.pyplot as plt
        import numpy as np
        from sklearn.datasets import load_digits
        from sklearn import decomposition
        from sklearn import preprocessing

        digits = load_digits()
        X = digits["data" ]/255.
        Y = digits["target"]
```

1.1 4 Implementation - Non-negative matrix factorization

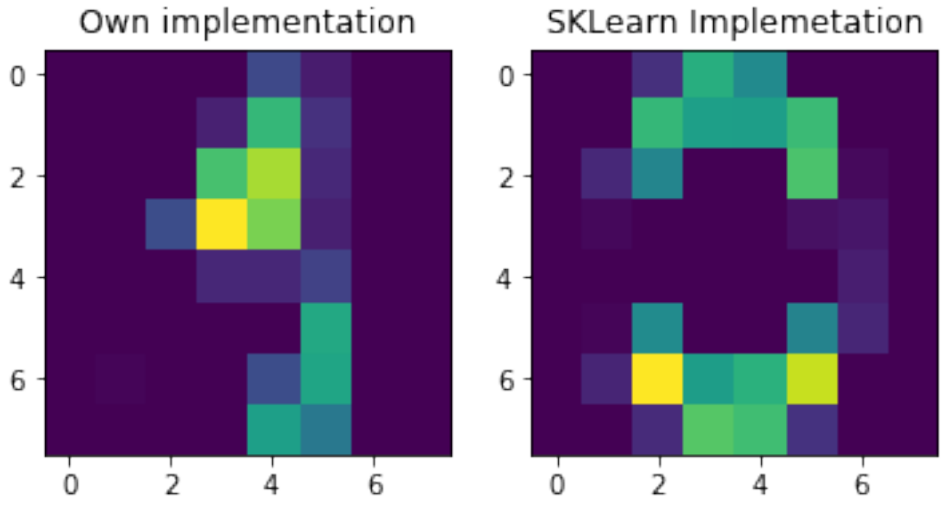
```
In [2]: def non_negative(data, num_components):

            X = data
            p = num_components
            m,n = data.shape

            #initialize H and W with positive normal random distribution
            H = np.absolute(np.random.standard_normal(size=(p,n)))
            W = np.absolute(np.random.standard_normal(size=(m,p)))

            # Iteration limit
            limit = 1000

            for i in range(limit):
                H = H * (np.dot(W.T,X)) / np.clip((np.dot(W.T,np.dot(W,H))), a_min = 0.01, a_max
                W = W * (np.dot(X,H.T)) / np.clip((np.dot(W, np.dot(H,H.T))), a_min = 0.01, a_ma

            return W, H
```

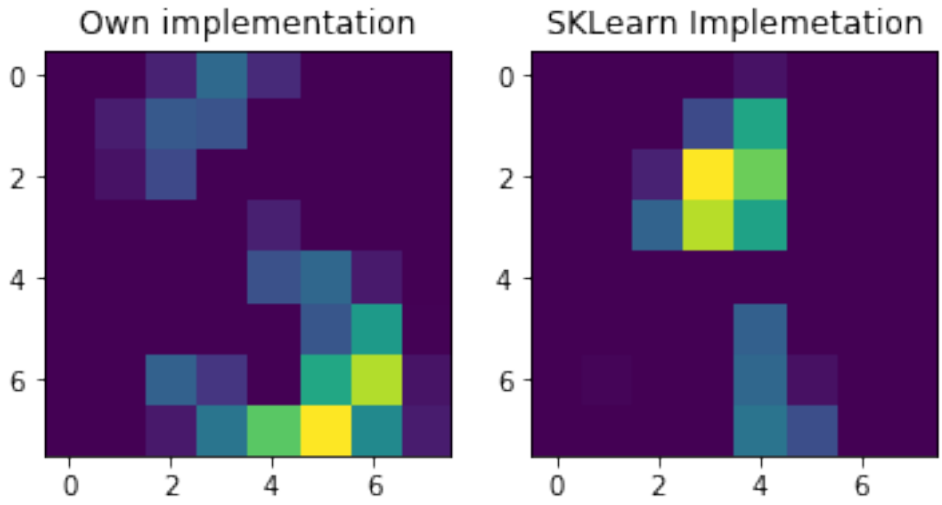
```
In [3]: W, H = non_negative(X, 10)
        print(W.shape,H.shape)
```

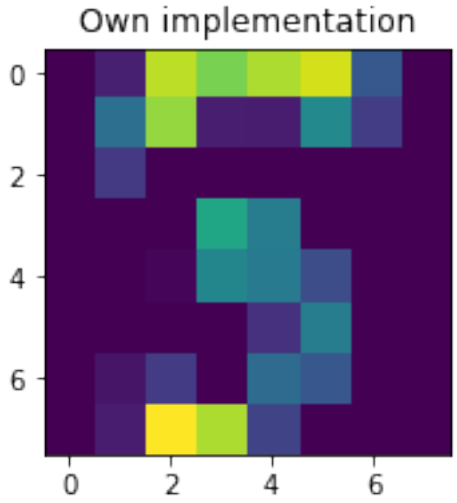
```
(1797, 10) (10, 64)
```

In [4]:
```
model = decomposition.NMF(n_components=10, init='random', random_state=0)
W_skl = model.fit_transform(X)
H_skl = model.components_
```

In [5]:
```
for i in range(10):
    fig = plt.figure()
    a=fig.add_subplot(1,2,1)
    plt.imshow(H[i,:].reshape(8,8))
    a.set_title('Own implementation')
    a=fig.add_subplot(1,2,2)
    plt.imshow(H_skl[i,:].reshape(8,8))
    a.set_title('SKLearn Implemetation')
    plt.show()
```



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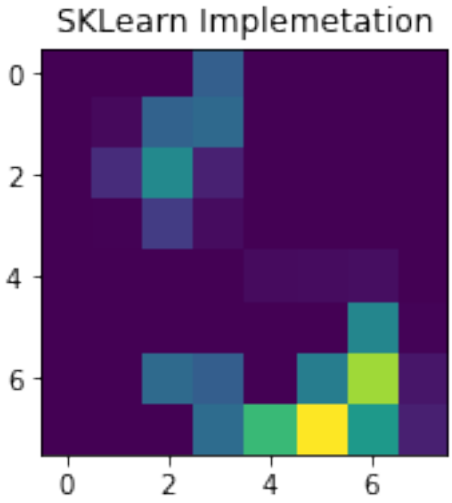
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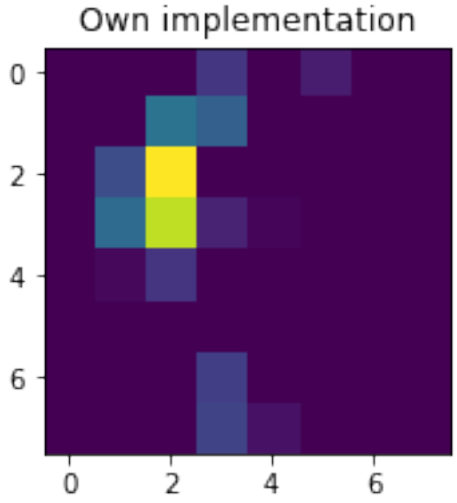
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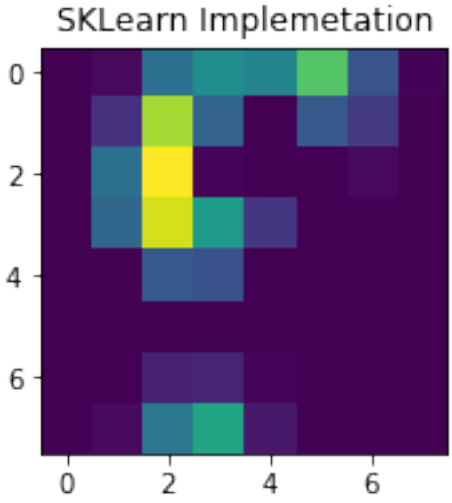
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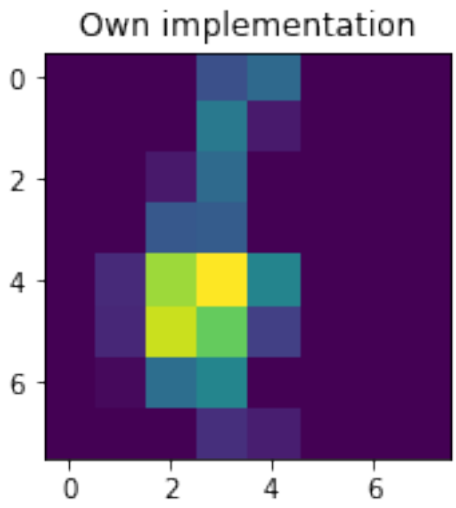
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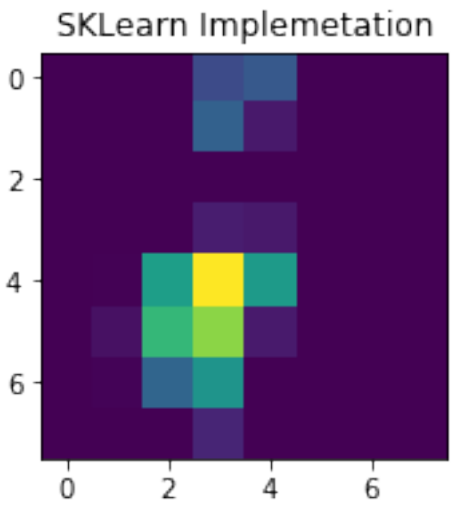
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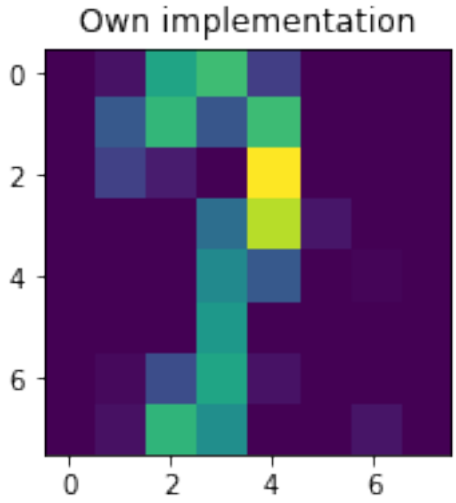
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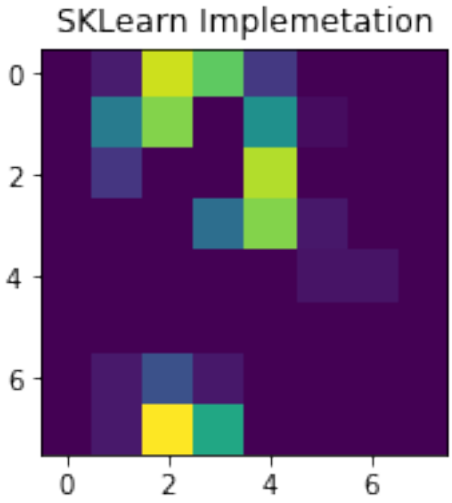
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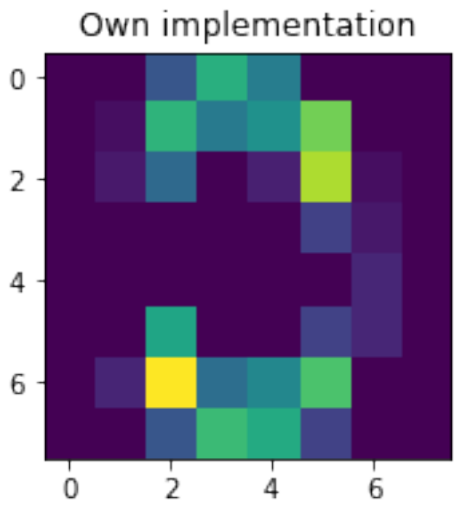
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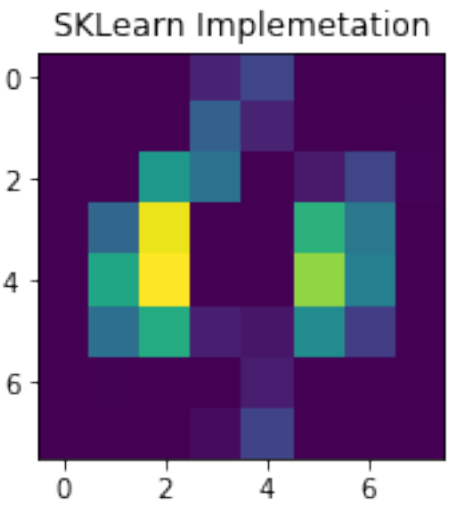
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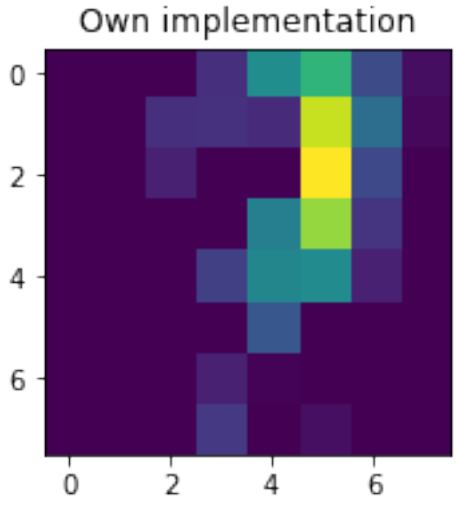
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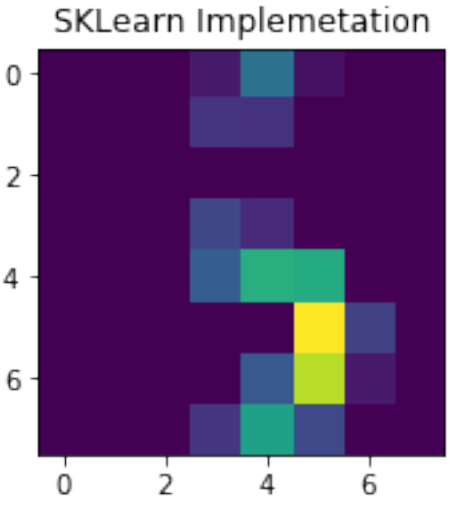
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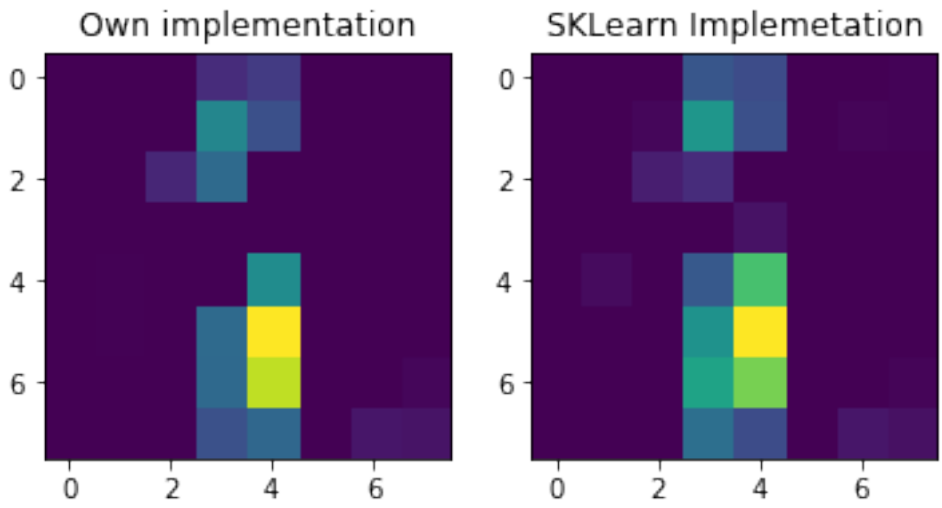

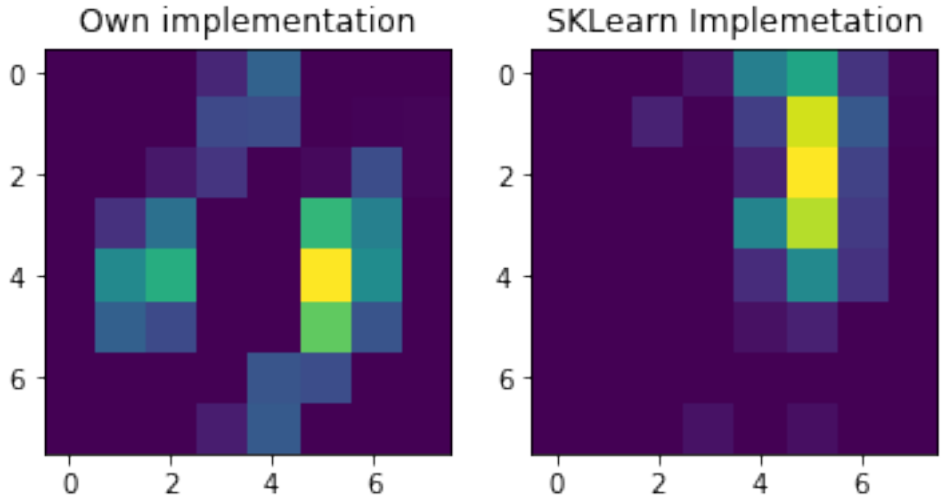

The results are comparable, although there are some images that don't look similar. This might be the case, because of the random initialization of W and H: The NMF is not unique but you can see prototypical parts of the numbers.

1.2 5 Recommender System

```
In [6]: import pandas as pd

        # column headers for the dataset
        ratings_cols = ['user id','movie id','rating','timestamp']
        movies_cols = ['movie id','movie title','release date',
        'video release date','IMDb URL','unknown','Action',
```

```
        'Adventure','Animation','Childrens','Comedy','Crime',
        ' Documentary','Drama','Fantasy','Film-Noir','Horror',
        'Musical','Mystery','Romance','Sci-Fi','Thriller',
        'War' ,'Western']
        users_cols = ['user id','age','gender','occupation',
        'zip code']

        users = pd.read_csv('ml-100k/u.user', sep ='|',
                            names = users_cols, encoding ='latin-1')
        movies = pd.read_csv('ml-100k/u.item', sep='|',
                            names = movies_cols , encoding ='latin-1')
        ratings = pd.read_csv('ml-100k/u.data', sep ='\t',
                            names = ratings_cols , encoding ='latin-1 ')

        # peek at the dataframes , if you like :)
        users.head()
        movies.head()
        ratings.head()

        # create a joint ratings dataframe for the matrix
        fill_value = 0
        rat_df = ratings.pivot(index = 'user id',
        columns ='movie id', values = 'rating').fillna(fill_value)
        rat_df.head()
```

Out[6]:

movie id	1	2	3	4	5	6	7	8	9	10	...	\
user id											...	
1	5.0	3.0	4.0	3.0	3.0	5.0	4.0	1.0	5.0	3.0	...	
2	4.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	...	
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	
5	4.0	3.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	

movie id	1673	1674	1675	1676	1677	1678	1679	1680	1681	1682
user id										
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[5 rows x 1682 columns]

In [7]:
```
W, H = non_negative(rat_df, 30)
print(rat_df.shape, W.shape,H.shape)
```

```
(943, 1682) (943, 30) (30, 1682)
```

```
In [8]: def recommend_movies(reconstruction, user_id, movies, ratings):
            rec = reconstruction.iloc[user_id].as_matrix()
            ratings = ratings.as_matrix()
            rec_sort_idx = np.argsort(rec)[::-1]

            rec_idx = np.where(ratings[user_id-1, rec_sort_idx] == 0)[0][0]

            print("Recommended film based on your ratings: " + movies.iloc[rec_idx].at['movie ti
                  " " + movies.iloc[rec_idx].at['IMDb URL'])

        reconstruction = pd.DataFrame(W @ H, columns = rat_df.columns)
        for i in range(200):
            predictions = recommend_movies(reconstruction, i+1, movies, rat_df)
```

```
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Four Rooms (1995) http://us.imdb.com/M/title-exact?Four%
Recommended film based on your ratings: Shanghai Triad (Yao a yao yao dao waipo qiao) (1995) htt
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: GoldenEye (1995) http://us.imdb.com/M/title-exact?Golden
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In [9]: W, H = non_negative(rat_df, 30)
        reconstruction = pd.DataFrame(W @ H, columns = rat_df.columns)
        for i in range(200):
            predictions = recommend_movies(reconstruction, i+1, movies, rat_df)
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The random initialization has an influence on the recommendation. If I run the NMF several times with the same number of components, the recommendation changes. One reason could be that the NMF is not a unique factorization and the results can be different.

```
In [10]: # Try the recommendation with 100 components
         W, H = non_negative(rat_df, 100)
         print(rat_df.shape, W.shape,H.shape)
         reconstruction = pd.DataFrame(W @ H, columns = rat_df.columns)
         for i in range(200):
             predictions = recommend_movies(reconstruction, i+1, movies, rat_df)
```

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Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Get Shorty (1995) http://us.imdb.com/M/title-exact?Get%2
Recommended film based on your ratings: Get Shorty (1995) http://us.imdb.com/M/title-exact?Get%2
Recommended film based on your ratings: GoldenEye (1995) http://us.imdb.com/M/title-exact?Golden
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Copycat (1995) http://us.imdb.com/M/title-exact?Copycat%
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: GoldenEye (1995) http://us.imdb.com/M/title-exact?Golden
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Four Rooms (1995) http://us.imdb.com/M/title-exact?Four%
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
```

```
Recommended film based on your ratings: GoldenEye (1995) http://us.imdb.com/M/title-exact?Golden
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Four Rooms (1995) http://us.imdb.com/M/title-exact?Four%
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
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Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
Recommended film based on your ratings: Toy Story (1995) http://us.imdb.com/M/title-exact?Toy%20
```

Here one can see that the choose of the number of parameters has an influence on the recommendation.

1.2.1 Try to find prototypical users

```
In [11]: comp = 10
         W, H = non_negative(rat_df, comp)

In [12]: movies_cols = np.array(movies_cols)
         H_sorted = np.argsort(H, axis = 1)[:,::-1]

         for c in range(comp):
             print("Top ten genres of prototypical user {}:".format(c+1))
             a = H_sorted[c,0:9]
             for idx in a:
                 print(movies_cols[movies.iloc[idx].as_matrix() == 1])
```

```
Top ten genres of prototypical user 1:
['Action' 'Crime' 'Drama']
['Drama' 'War']
['Drama']
['Drama']
['Drama' 'Thriller']
['Action' 'Adventure']
['Action' 'Crime' 'Drama']
['Comedy' 'Romance' 'War']
['Crime' 'Drama']
Top ten genres of prototypical user 2:
['Action' 'Adventure' 'Romance' 'Sci-Fi' 'War']
['Action' 'Adventure' 'Romance' 'Sci-Fi' 'War']
['Action' 'Adventure' 'Comedy' 'Romance']
['Action' 'Adventure' 'Sci-Fi']
['Action' 'Adventure']
['Action' 'Adventure' 'Sci-Fi']
['Action' 'Adventure' 'Drama' 'Romance' 'Sci-Fi' 'War']
['Comedy']
['movie id' 'Animation' 'Childrens' 'Comedy']
Top ten genres of prototypical user 3:
```

```
['Comedy' 'Romance']
['Drama']
['Comedy' 'Romance']
['Drama']
['Comedy' 'Romance']
['Drama']
['Drama' 'War']
['Comedy' 'Romance']
['Drama']
Top ten genres of prototypical user 4:
['Action' 'Drama' 'Romance']
['Action' 'Thriller']
['Drama' 'Sci-Fi']
['Crime' 'Film-Noir' 'Mystery' 'Thriller']
['Action' 'Mystery' 'Romance' 'Thriller']
['Drama' 'Romance' 'War']
['Drama']
['Horror' 'Thriller']
['Mystery' 'Thriller']
Top ten genres of prototypical user 5:
['Drama']
['Crime' 'Thriller']
['Crime' 'Drama']
['Comedy']
['Crime' 'Thriller']
['Sci-Fi']
['Drama' 'Sci-Fi']
['Comedy']
['Comedy' 'Drama' 'Musical']
Top ten genres of prototypical user 6:
['Animation' 'Childrens' 'Musical']
['Animation' 'Childrens' 'Musical']
['Animation' 'Childrens' 'Musical']
['Animation' 'Childrens' 'Comedy' 'Musical']
['Childrens' 'Comedy' 'Musical']
['Animation' 'Childrens' 'Musical']
['Animation' 'Childrens' 'Musical']
['Comedy']
['Animation' 'Childrens']
Top ten genres of prototypical user 7:
['Drama' 'Romance']
['Drama']
['Drama']
['Drama' 'Romance']
['Drama' 'Romance' 'War']
['Drama' 'Mystery']
['Crime' 'Drama' 'Thriller']
['Comedy']
```

```
['Comedy']
Top ten genres of prototypical user 8:
['Action' 'Thriller']
['Action' 'Thriller']
['Action' 'Sci-Fi' 'Thriller']
['Action' 'Adventure' 'Comedy' 'Romance']
['Action' 'Adventure' 'Thriller']
['Action' 'Sci-Fi' 'Thriller']
['Action']
['Action' 'Thriller']
['Action' 'Drama' 'War']
Top ten genres of prototypical user 9:
['Mystery' 'Thriller']
['Film-Noir' 'Mystery']
['Comedy' 'Thriller']
['Action' 'Adventure' 'Romance' 'War']
['Drama' 'War']
['Drama' 'Romance' 'War']
['Mystery' 'Thriller']
['Comedy' 'Crime']
['Drama']
Top ten genres of prototypical user 10:
['Action' 'Adventure' 'Thriller']
['Drama' 'Romance']
['Action' 'Sci-Fi' 'War']
['movie id' 'Animation' 'Childrens' 'Comedy']
['Drama' 'Thriller']
['Action' 'Adventure' 'Mystery']
['Action' 'Adventure' 'Romance' 'Sci-Fi' 'War']
['Crime' 'Drama' 'Thriller']
['Action' 'Adventure' 'Romance' 'Sci-Fi' 'War']
```

Here one can see that there are several prototypical users e.g. : - User 1 likes action movies - User 3 likes crime and thriller - User 5 likes comedy and romance - User 7 likes animation and children - etc.