matrix_factorizations_1

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1 Matrix Factorization Visualizations - Method 1 (Code from Homework 5)

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```
In [1]: import numpy as np
        import matplotlib.pyplot as plt
        import pandas as pd
```

```
In [80]: def grad_U(Ui, Yij, Vj, reg, eta):
             """
             Takes as input Ui (the ith row of U), a training point Yij, the column
             vector Vj (jth column of V^T), reg (the regularization parameter lambda),
             and eta (the learning rate).

             Returns the gradient of the regularized loss function with
             respect to Ui multiplied by eta.
             """

             grad = reg*Ui - Vj*(Yij - np.dot(Ui, Vj))

             return eta*grad

         def grad_V(Vj, Yij, Ui, reg, eta):
             """
             Takes as input the column vector Vj (jth column of V^T), a training point Yij,
             Ui (the ith row of U), reg (the regularization parameter lambda),
             and eta (the learning rate).

             Returns the gradient of the regularized loss function with
             respect to Vj multiplied by eta.
             """

             grad = reg*Vj - Ui*(Yij - np.dot(Ui, Vj))

             return eta*grad
```

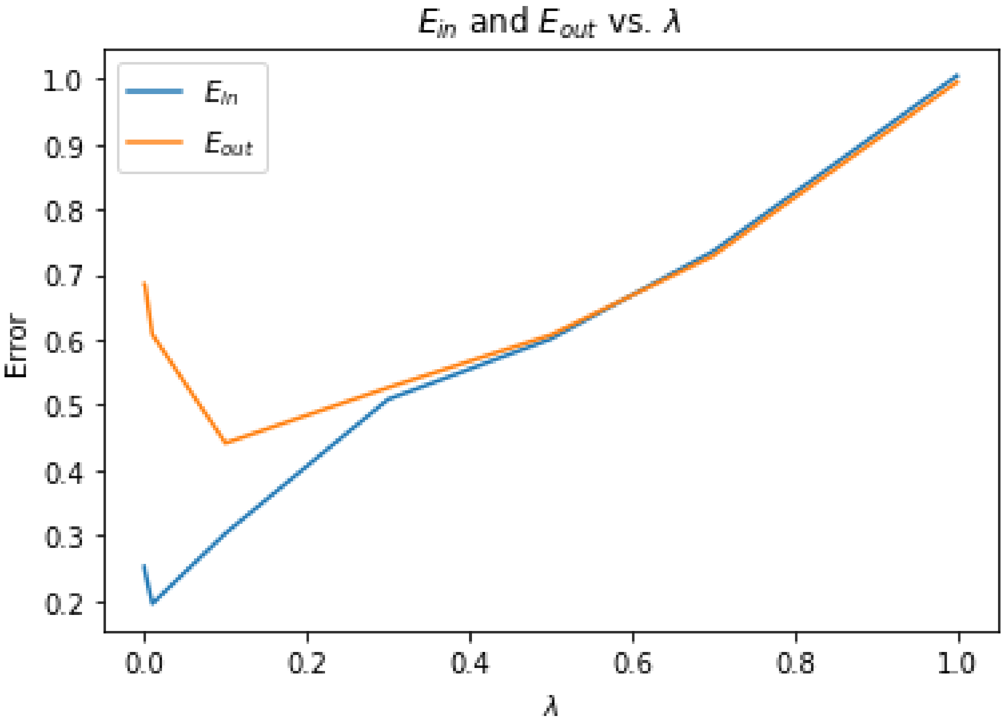
```python
def get_err(U, V, Y, reg=0.0):
    """
    Takes as input a matrix Y of triples (i, j, Y_ij) where i is the index of a user,
    j is the index of a movie, and Y_ij is user i's rating of movie j and
    user/movie matrices U and V.

    Returns the mean regularized squared-error of predictions made by
    estimating Y_{ij} as the dot product of the ith row of U and the jth column of V^
    """

    error = 0.5*reg*(np.linalg.norm(U, 'fro')**2 + np.linalg.norm(V, 'fro')**2)

    for k in range(len(Y)):
        Yij = Y[k][2]
        i = Y[k][0] - 1
        j = Y[k][1] - 1
        error += 0.5*(Yij - np.dot(U[i,:], V[j,:]))**2

    return error / len(Y) # mean error

def train_model(M, N, K, eta, reg, Y, eps=0.0001, max_epochs=300):
    """
    Given a training data matrix Y containing rows (i, j, Y_ij)
    where Y_ij is user i's rating on movie j, learns an
    M x K matrix U and N x K matrix V such that rating Y_ij is approximated
    by (UV^T)_ij.

    Uses a learning rate of <eta> and regularization of <reg>. Stops after
    <max_epochs> epochs, or once the magnitude of the decrease in regularized
    MSE between epochs is smaller than a fraction <eps> of the decrease in
    MSE after the first epoch.

    Returns a tuple (U, V, err) consisting of U, V, and the unregularized MSE
    of the model.
    """

    # initialize entries of U and V uniformly and randomly in [-0.5, 0.5]
    U = np.random.rand(M, K) - 0.5*np.ones([M, K])
    V = np.random.rand(N, K) - 0.5*np.ones([N, K])

    epochs = 0
    rel_red = np.inf
    err = get_err(U, V, Y, reg)

    while epochs < max_epochs and rel_red > eps:
        # store previous error
        prev_err = np.copy(err)
        # shuffle training data
        order = np.random.permutation(len(Y))

        # perform SGD
        for o in order:
            i = Y[o][0] - 1
            j = Y[o][1] - 1
            Yij = Y[o][2]
            Ui = U[i,:]
            Vj = V[j,:]

            U[i,:] -= grad_U(Ui, Yij, Vj, reg, eta)
            V[j,:] -= grad_V(Vj, Yij, Ui, reg, eta)

        # compute error and loss reduction
        err = get_err(U, V, Y, reg)
        loss_red = err - prev_err

        # store initial loss reduction for comparison
        if epochs == 0:
            init_red = np.copy(loss_red)

        # compute relative loss reduction
        rel_red = loss_red/init_red
        epochs += 1

    return (U, V, err)
```

In [81]:

```
# factorize using SGD as in Homework 5
Y_train = np.loadtxt('./data/train2.txt').astype(int)
Y_test = np.loadtxt('./data/test2.txt').astype(int)

M = max(max(Y_train[:,0]), max(Y_test[:,0])).astype(int) # users
N = max(max(Y_train[:,1]), max(Y_test[:,1])).astype(int) # movies
k = 20

regs = [10**-4, 10**-3, 10**-2, 10**-1, 0.3, 0.5, 0.7, 1]
eta = 0.03 # learning rate
E_ins = []
E_outs = []

# Use to compute Ein and Eout
for reg in regs:

    print("Training model with M = %s, N = %s, k = %s, eta = %s, reg = %s"%(M, N, k, e
    U, V, e_in = train_model(M, N, k, eta, reg, Y_train)
    e_out = get_err(U, V, Y_test)
```

```
            E_ins.append(e_in)
            E_outs.append(e_out)

Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 0.0001
Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 0.001
Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 0.01
Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 0.1
Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 0.3
Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 0.5
Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 0.7
Training model with M = 943, N = 1664, k = 20, eta = 0.03, reg = 1
```

```
In [82]: # Plot values of E_in across k for each value of lambda
         plt.figure()
         plt.plot(regs, E_ins)
         plt.plot(regs, E_outs)
         plt.title('$E_{in}$ and $E_{out}$ vs. $\lambda$')
         plt.xlabel('$\lambda$')
         plt.ylabel('Error')
         plt.legend(['$E_{in}$', '$E_{out}$'])
         plt.savefig('matrix_1_reg.png')
```



```
In [89]: E_outs
```

```
Out[89]: [0.6854140619862172,
          0.6836143075097076,
          0.6081313620287249,
          0.44147675467734,
          0.526633970830529,
          0.6070052718322477,
          0.7286440157051878,
          0.9949934500669039]
```

```
In [83]: # load data from cleaned files
         movies = pd.read_csv('data/movies.csv')
         data = pd.read_csv('data/data.csv').astype(int)
         train_data = np.loadtxt('./data/data2.txt').astype(int)
```

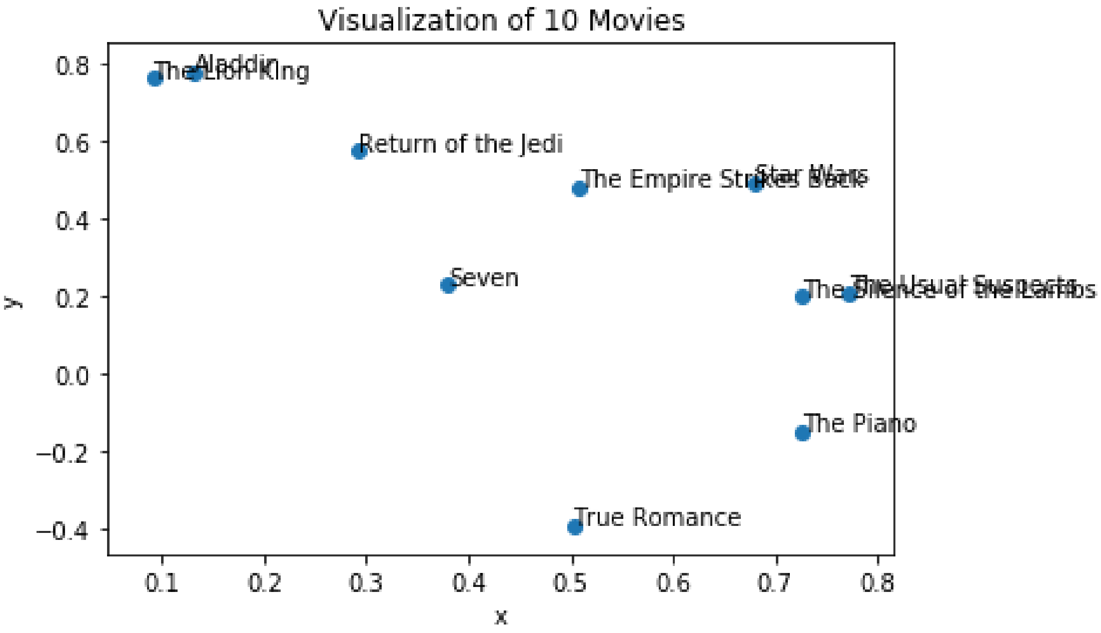
```
In [84]: # train using best lambda on entire dataset
         M = max(data['User']) # users
         N = max(data['Movie']) # movies

         U, V, e_in = train_model(M, N, k, eta, 0.1, train_data)

         # note that U is Mxk and V is Nxk, so we transpose them to be consistent
         # with the convention used in the Miniproject 2 pdf
         U = U.T
         V = V.T
```

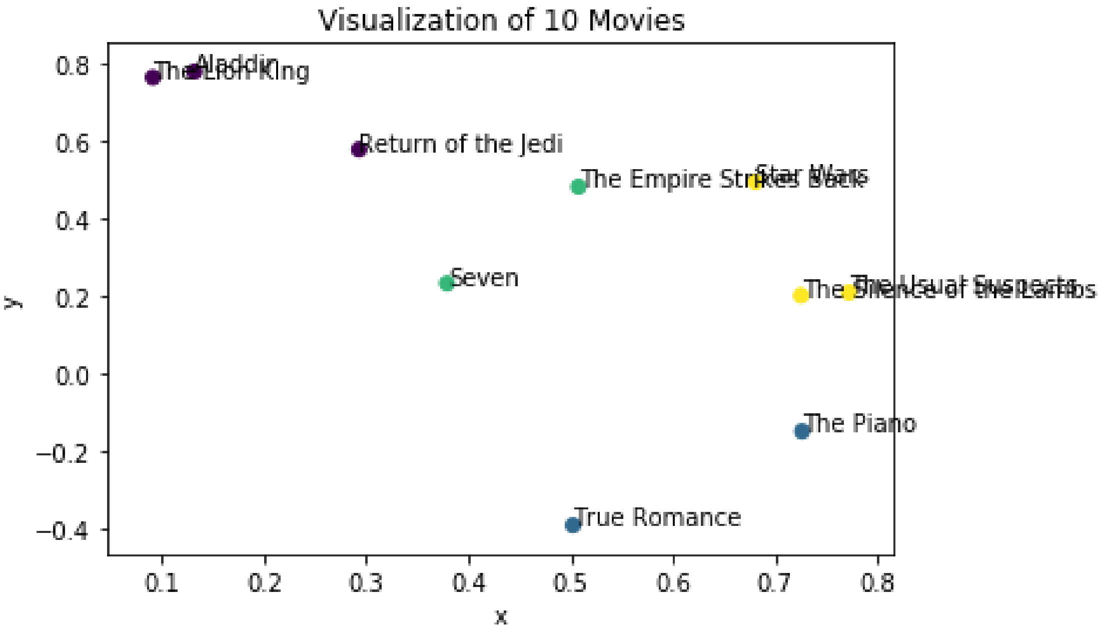
```
In [85]: # mean-centering
         V_mean = V.mean(axis=1)
         for i in range(N):
             V[:,i] -= V_mean
         for i in range(M):
             U[:,i] -= V_mean

         # get SVD of V
         A, S, B = np.linalg.svd(V)
```

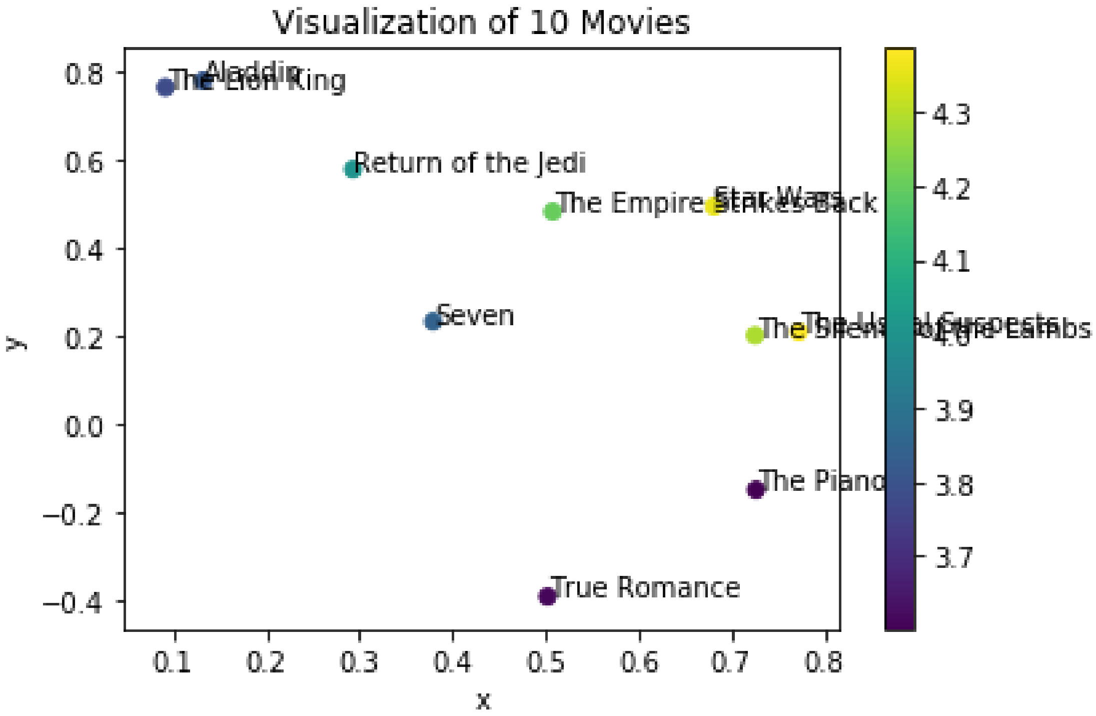
```
In [86]: # project U, V into K-dimensional space
         K = 2
         U_tilde = np.matmul(A.T[:K], U)
         V_tilde = np.matmul(A.T[:K], V)
```

```
In [129]: # visualize any 10 movies
          ids = [11, 12, 71, 95, 98, 92, 578, 181, 172, 50]

          titles = ['Seven', 'The Usual Suspects', 'The Lion King', 'Aladdin', 'The Silence of

          x = [0]*10
          y = [0]*10
          for i in range(len(ids)):
              x[i] = V_tilde[0][ids[i]-1]
```

```
    y[i] = V_tilde[1][ids[i]-1]

fig, ax = plt.subplots()
plt.scatter(x, y)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.savefig('matrix_1_a.png')

# run k-means to cluster points
from sklearn.cluster import KMeans

X = np.column_stack((x, y))
labels = KMeans(n_clusters=4, random_state=0).fit_predict(X)

fig, ax = plt.subplots()
plt.scatter(x, y, c=labels)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.savefig('matrix_1_a_clusters.png')

# visualize movies by their average ratings
ratings = []
for i in ids:
    ratings.append(movies['avg_rating'][i-1])

fig, ax = plt.subplots()
plt.scatter(x, y, c=ratings)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.colorbar()
plt.savefig('matrix_1_a_ratings.png')
```


Visualization of 10 Movies
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
y
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x
The Lion King
Aladdin
Return of the Jedi
The Empire Strikes Back
Star Wars
Seven
The Silence of the Lambs
The Usual Suspects
The Piano
True Romance


Visualization of 10 Movies
0.8
0.6
0.4
0.2
0.0
−0.2
−0.4
y
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
x
The Lion King
Aladdin
Return of the Jedi
The Empire Strikes Back
Star Wars
Seven
The Silence of the Lambs
The Usual Suspects
The Piano
True Romance

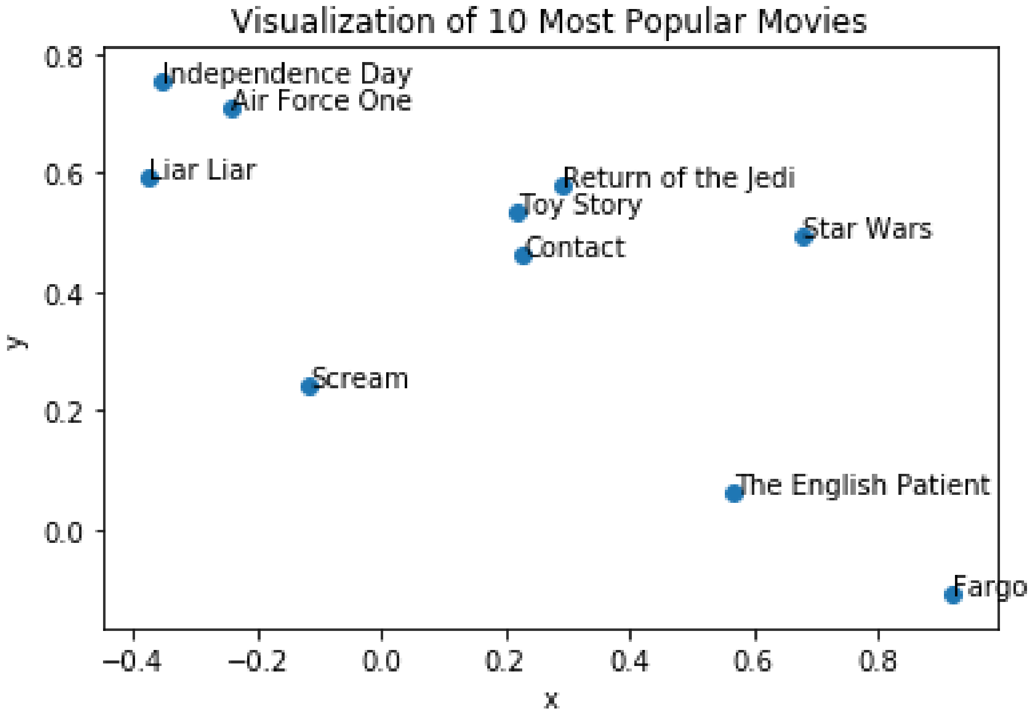


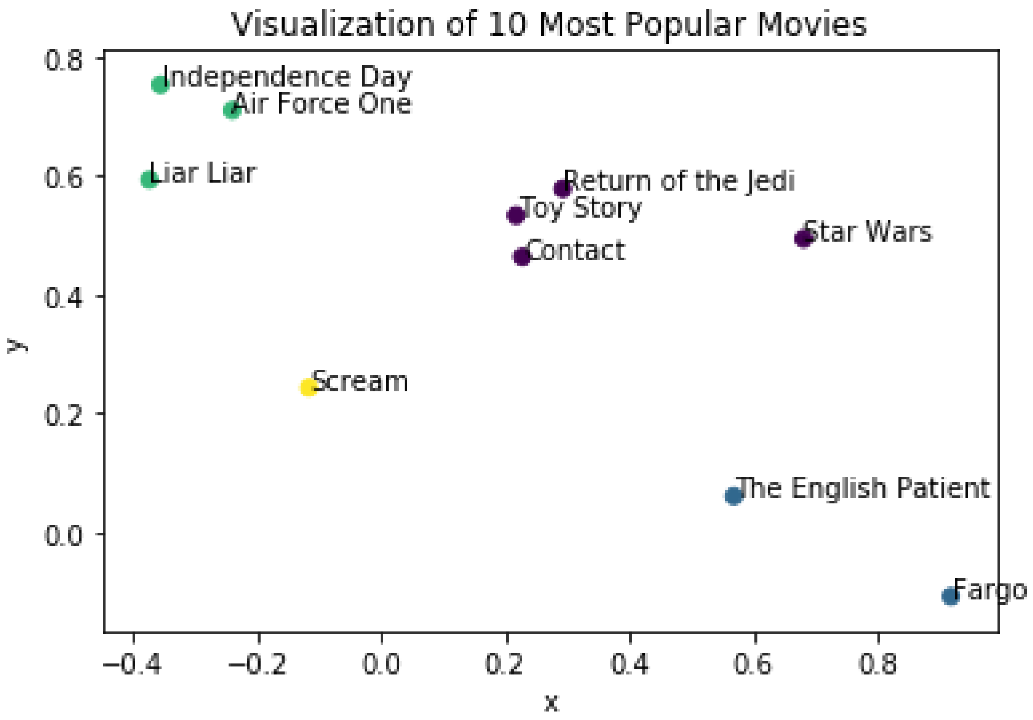
```
In [131]: # visualize 10 most popular movies
          pop = data['Movie'].value_counts().head(10).index

          for i in pop:
              print(movies[movies['ID'] == i]['Title'])

          titles = ['Star Wars', 'Contact', 'Fargo', 'Return of the Jedi', 'Liar Liar', 'The E

          x = [0]*10
          y = [0]*10
          for i in range(len(pop)):
              x[i] = V_tilde[0][pop[i]-1]
              y[i] = V_tilde[1][pop[i]-1]

          # clustering
          X = np.column_stack((x, y))
          labels = KMeans(n_clusters=4, random_state=0).fit_predict(X)

          # plot visualization
          fig, ax = plt.subplots()
          plt.scatter(x, y)

          for i, txt in enumerate(titles):
              ax.annotate(txt, (x[i], y[i]))
```

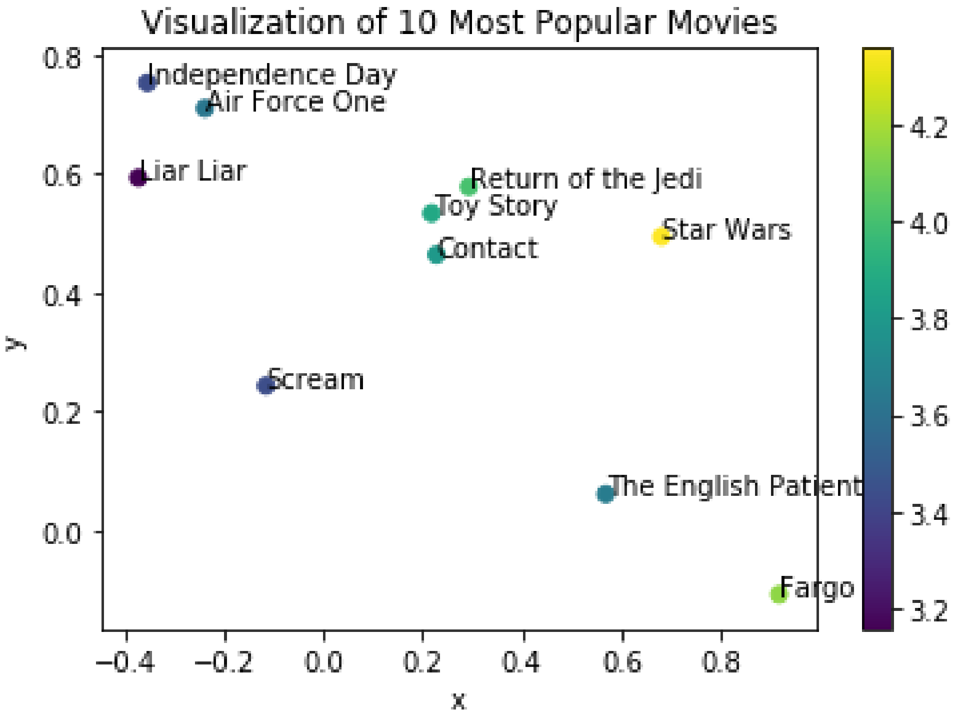
```
        plt.title('Visualization of 10 Most Popular Movies')
        plt.xlabel('x')
        plt.ylabel('y')
        plt.savefig('matrix_1_b.png')

        # plot clusters
        fig, ax = plt.subplots()
        plt.scatter(x, y, c=labels)

        for i, txt in enumerate(titles):
            ax.annotate(txt, (x[i], y[i]))

        plt.title('Visualization of 10 Most Popular Movies')
        plt.xlabel('x')
        plt.ylabel('y')
        plt.savefig('matrix_1_b_clusters.png')

        # visualize movies by their average ratings
        ratings = []
        for i in pop:
            ratings.append(movies['avg_rating'][i-1])

        fig, ax = plt.subplots()
        plt.scatter(x, y, c=ratings)

        for i, txt in enumerate(titles):
            ax.annotate(txt, (x[i], y[i]))

        plt.title('Visualization of 10 Most Popular Movies')
        plt.xlabel('x')
        plt.ylabel('y')
        plt.colorbar()
        plt.savefig('matrix_1_b_ratings.png')
```

```
49    Star Wars (1977)
Name: Title, dtype: object
257    Contact (1997)
Name: Title, dtype: object
99    Fargo (1996)
Name: Title, dtype: object
180    Return of the Jedi (1983)
Name: Title, dtype: object
292    Liar Liar (1997)
Name: Title, dtype: object
284    English Patient, The (1996)
Name: Title, dtype: object
286    Scream (1996)
```

```
Name: Title, dtype: object
0    Toy Story (1995)
Name: Title, dtype: object
298    Air Force One (1997)
Name: Title, dtype: object
120    Independence Day (ID4) (1996)
Name: Title, dtype: object
```



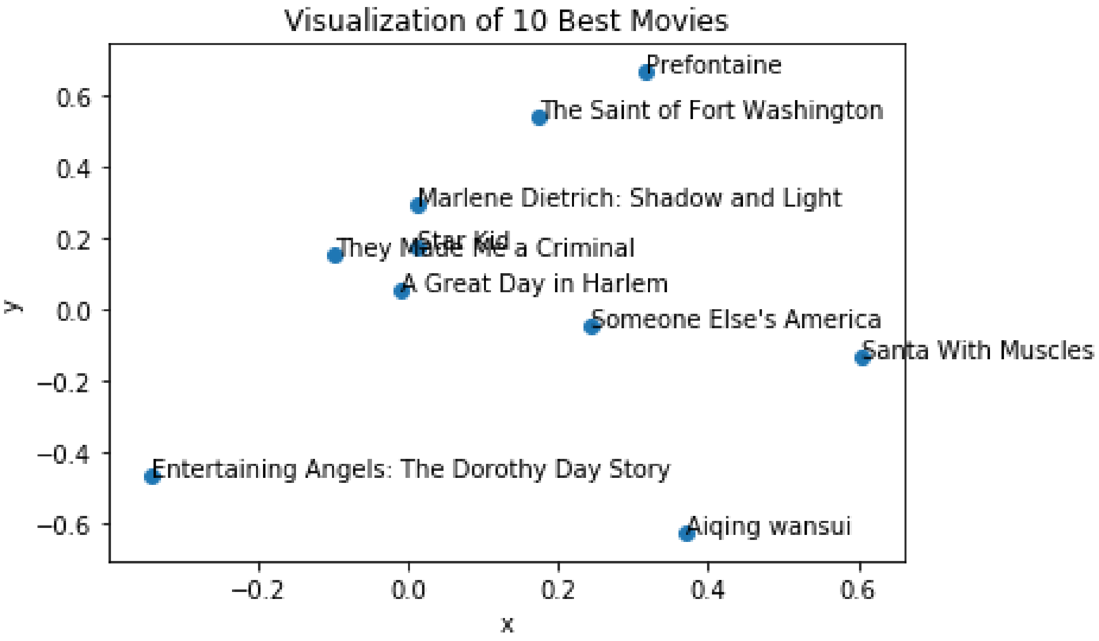

Visualization of 10 Most Popular Movies
Independence Day
Air Force One
Liar Liar
Return of the Jedi
Toy Story
Star Wars
Contact
Scream
The English Patient
Fargo
0.8
0.6
0.4
0.2
0.0
y
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
x

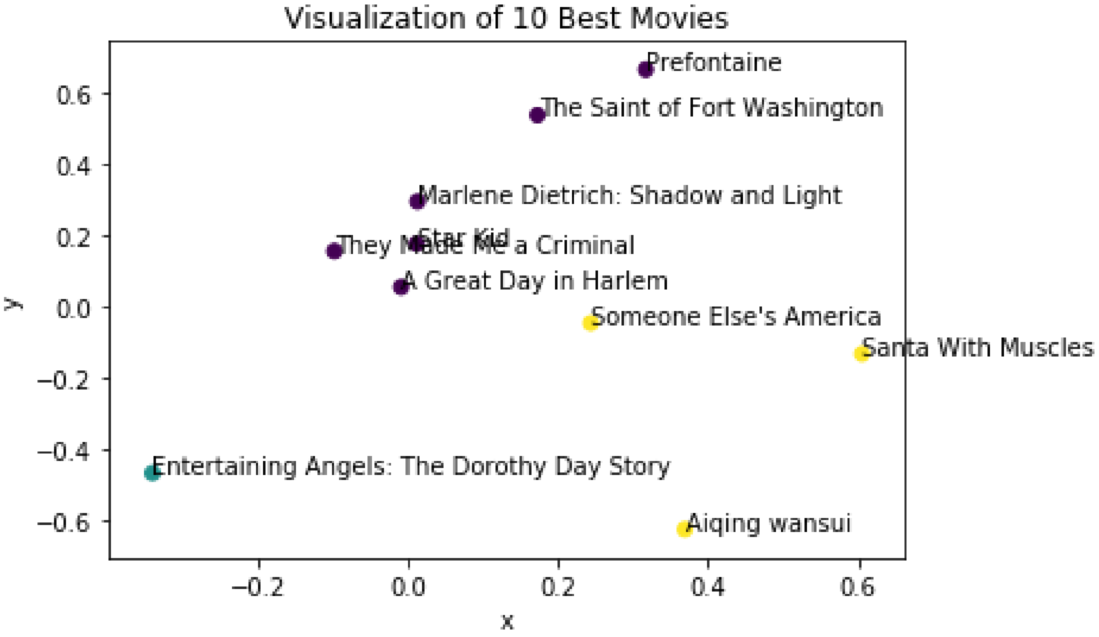

Visualization of 10 Most Popular Movies
Independence Day
Air Force One
Liar Liar
Return of the Jedi
Toy Story
Star Wars
Contact
Scream
The English Patient
Fargo
0.8
0.6
0.4
0.2
0.0
y
−0.4
−0.2
0.0
0.2
0.4
0.6
0.8
x
4.2
4.0
3.8
3.6
3.4
3.2

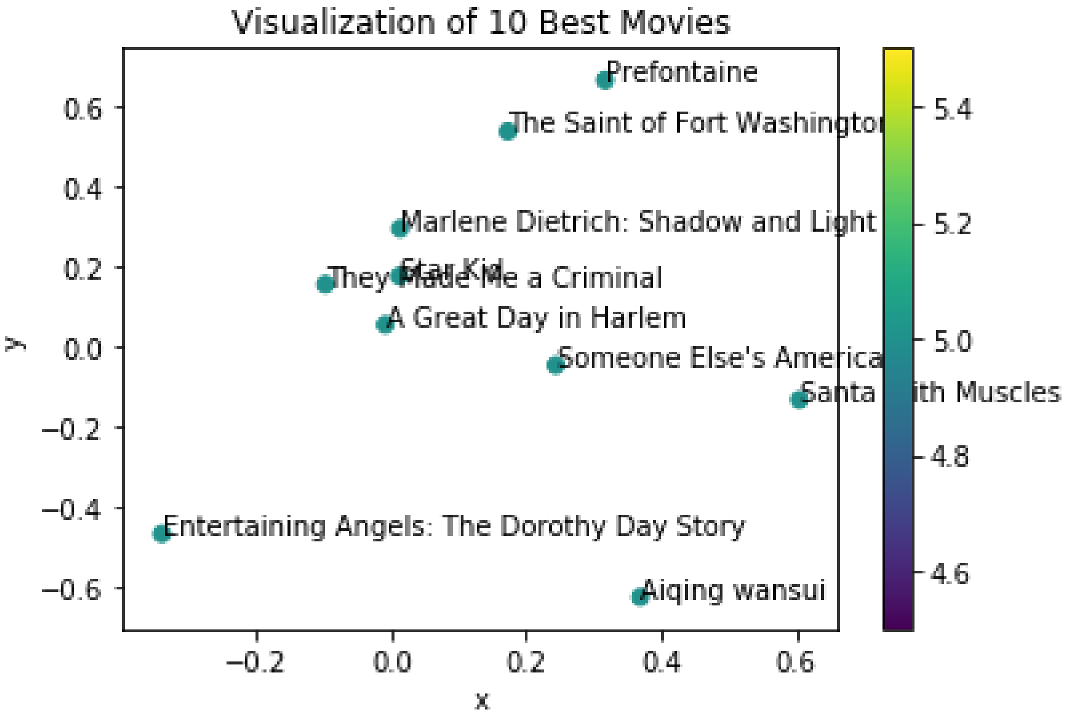
```
In [133]: # visualize 10 best movies
          sorted_df = movies.sort_values(by='avg_rating', ascending=False)
          best = sorted_df.head(10)['ID']

          for i in best:
              print(movies[movies['ID'] == i]['Title'])

          titles = ["Someone Else's America", 'Prefontaine', 'Aiqing wansui', 'Star Kid', 'Ente

          x = [0]*10
          y = [0]*10
          count = 0
          for i in best:
              x[count] = V_tilde[0][i-1]
              y[count] = V_tilde[1][i-1]
              count += 1

          # clustering
          X = np.column_stack((x, y))
          labels = KMeans(n_clusters=3, random_state=0).fit_predict(X)

          # plot visualization
          fig, ax = plt.subplots()
          plt.scatter(x, y)

          for i, txt in enumerate(titles):
              ax.annotate(txt, (x[i], y[i]))

          plt.title('Visualization of 10 Best Movies')
          plt.xlabel('x')
          plt.ylabel('y')
          plt.savefig('matrix_1_c.png')

          # plot clusters
          fig, ax = plt.subplots()
          plt.scatter(x, y, c=labels)

          for i, txt in enumerate(titles):
              ax.annotate(txt, (x[i], y[i]))

          plt.title('Visualization of 10 Best Movies')
          plt.xlabel('x')
          plt.ylabel('y')
          plt.savefig('matrix_1_c_clusters.png')

          # visualize movies by their average ratings
          ratings = []
          for i in best:
```

```
    ratings.append(movies['avg_rating'][i-1])

fig, ax = plt.subplots()
plt.scatter(x, y, c=ratings)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Best Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.colorbar()
plt.savefig('matrix_1_c_ratings.png')
```

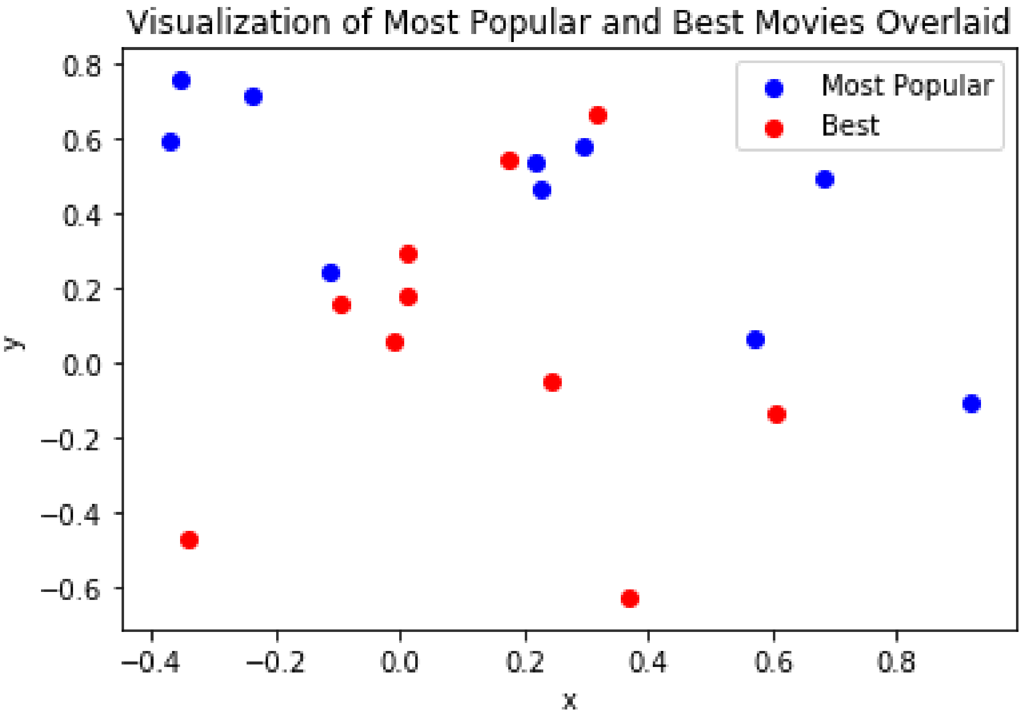
```
1588    Someone Else's America (1995)
Name: Title, dtype: object
1179    Prefontaine (1997)
Name: Title, dtype: object
1525    Aiqing wansui (1994)
Name: Title, dtype: object
1282    Star Kid (1997)
Name: Title, dtype: object
1637    Entertaining Angels: The Dorothy Day Story (1996)
Name: Title, dtype: object
1112    They Made Me a Criminal (1939)
Name: Title, dtype: object
1191    Marlene Dietrich: Shadow and Light (1996)
Name: Title, dtype: object
807    Great Day in Harlem, A (1994)
Name: Title, dtype: object
1456    Saint of Fort Washington, The (1993)
Name: Title, dtype: object
1489    Santa with Muscles (1996)
Name: Title, dtype: object
```


Visualization of 10 Best Movies
Prefontaine
The Saint of Fort Washington
Marlene Dietrich: Shadow and Light
Star Kid
They Made Me a Criminal
A Great Day in Harlem
Someone Else's America
Santa With Muscles
Entertaining Angels: The Dorothy Day Story
Aiqing wansui
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
y
−0.2
0.0
0.2
0.4
0.6
x


Visualization of 10 Best Movies
Prefontaine
The Saint of Fort Washington
Marlene Dietrich: Shadow and Light
Star Kid
They Made Me a Criminal
A Great Day in Harlem
Someone Else's America
Santa With Muscles
Entertaining Angels: The Dorothy Day Story
Aiqing wansui
0.6
0.4
0.2
0.0
−0.2
−0.4
−0.6
y
−0.2
0.0
0.2
0.4
0.6
x



In [146]:
```
# overlay best and most popular movies
x = [0]*20
y = [0]*20
count = 0

for i in pop:
    x[count] = V_tilde[0][i-1]
    y[count] = V_tilde[1][i-1]
    count += 1
for i in best:
    x[count] = V_tilde[0][i-1]
    y[count] = V_tilde[1][i-1]
    count += 1

fig, ax = plt.subplots()
plt.scatter(x[:10], y[:10], c='b')
plt.scatter(x[10:20], y[10:20], c='r')

plt.title('Visualization of Most Popular and Best Movies Overlaid')
plt.xlabel('x')
plt.ylabel('y')
plt.legend(['Most Popular', 'Best'])
plt.savefig('matrix_1_pop_best.png')
```

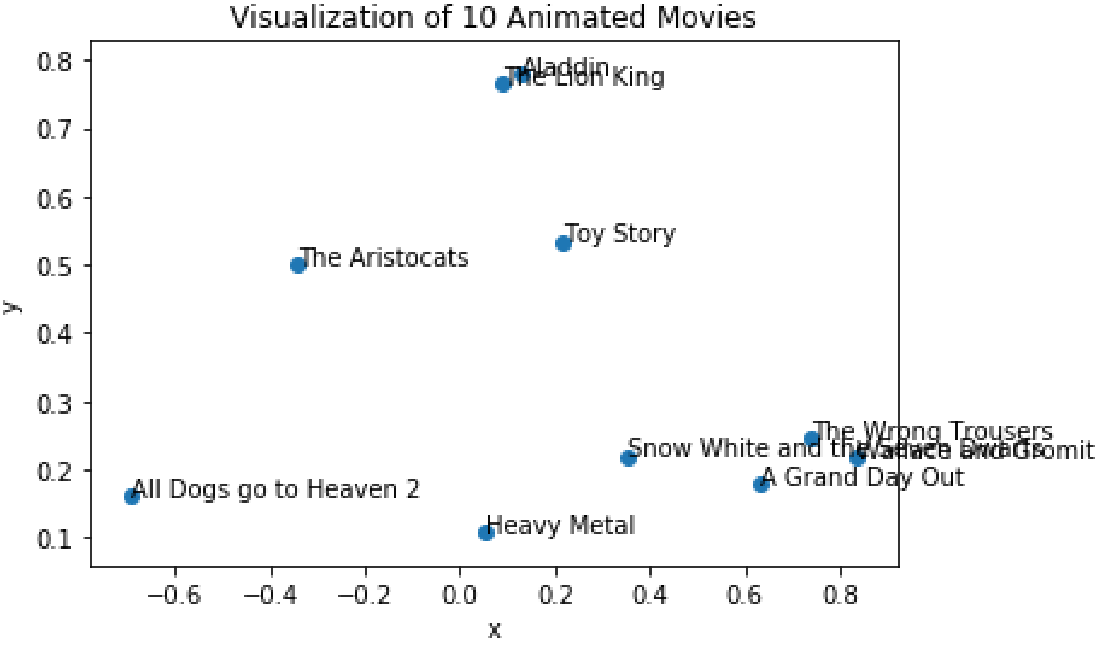


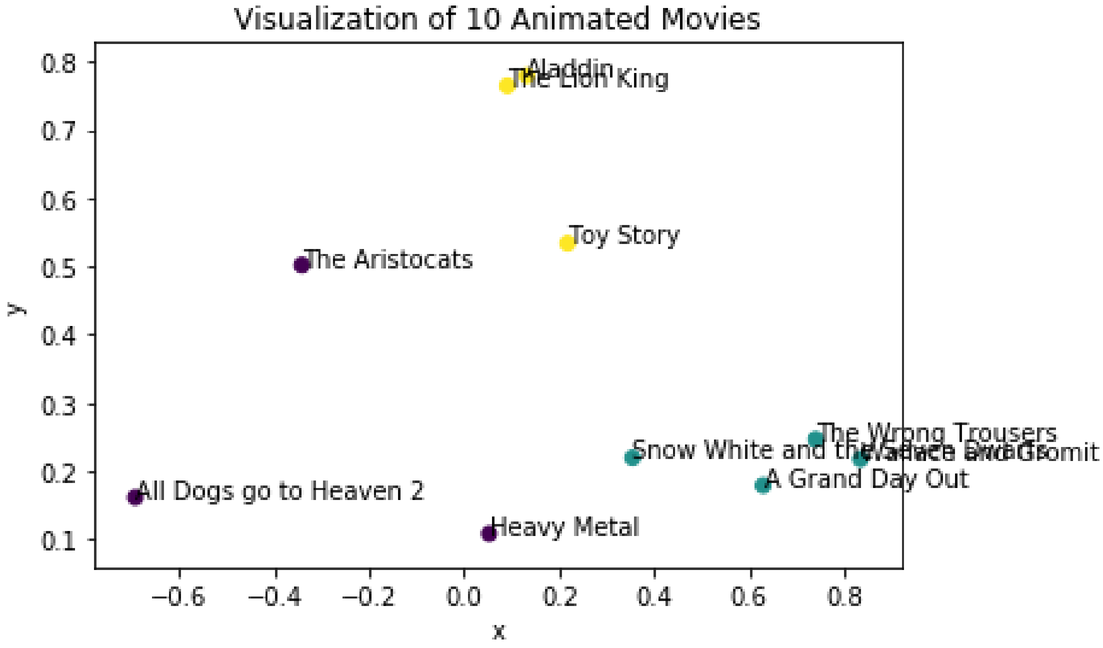
```
In [126]: # Visualize 10 animated movies
          # get all animated movies
          animated = movies[movies['Animation'] == 1]['ID'].head(10)

          for i in animated:
              print(movies[movies['ID'] == i]['Title'])

          titles = ['Toy Story', 'The Lion King', 'Aladdin', 'Snow White and the Seven Dwarfs'

          x = [0]*10
          y = [0]*10
          count = 0

          for i in animated:
              x[count] = V_tilde[0][i-1]
              y[count] = V_tilde[1][i-1]
              count += 1

          # clustering
          X = np.column_stack((x, y))
          labels = KMeans(n_clusters=3, random_state=0).fit_predict(X)

          # plot visualization
          fig, ax = plt.subplots()
```

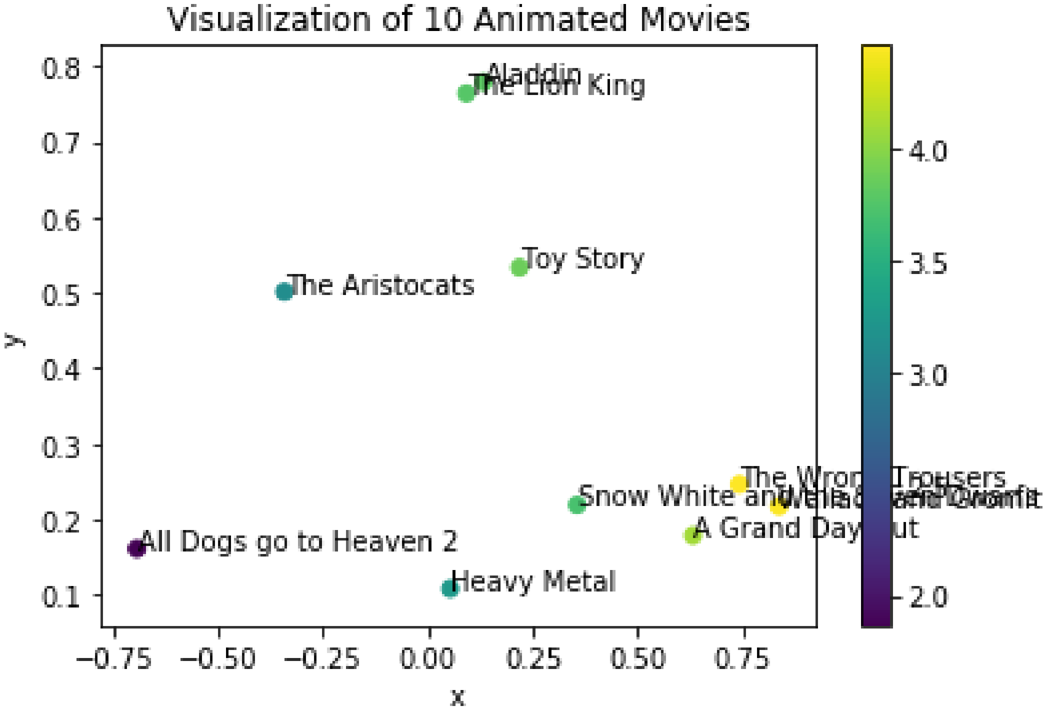
```python
    plt.scatter(x, y)

    for i, txt in enumerate(titles):
        ax.annotate(txt, (x[i], y[i]))

    plt.title('Visualization of 10 Animated Movies')
    plt.xlabel('x')
    plt.ylabel('y')
    plt.savefig('matrix_1_d_1.png')

    # plot clusters
    fig, ax = plt.subplots()
    plt.scatter(x, y, c=labels)

    for i, txt in enumerate(titles):
        ax.annotate(txt, (x[i], y[i]))

    plt.title('Visualization of 10 Animated Movies')
    plt.xlabel('x')
    plt.ylabel('y')
    plt.savefig('matrix_1_d_1_clusters.png')

    # visualize movies by their average ratings
    ratings = []
    for i in animated:
        ratings.append(movies['avg_rating'][i-1])

    fig, ax = plt.subplots()
    plt.scatter(x, y, c=ratings)

    for i, txt in enumerate(titles):
        ax.annotate(txt, (x[i], y[i]))

    plt.title('Visualization of 10 Animated Movies')
    plt.xlabel('x')
    plt.ylabel('y')
    plt.colorbar()
    plt.savefig('matrix_1_d_1_ratings.png')
```

```
0    Toy Story (1995)
Name: Title, dtype: object
70    Lion King, The (1994)
Name: Title, dtype: object
94    Aladdin (1992)
Name: Title, dtype: object
98    Snow White and the Seven Dwarfs (1937)
Name: Title, dtype: object
100    Heavy Metal (1981)
```

```
Name: Title, dtype: object
101    Aristocats, The (1970)
Name: Title, dtype: object
102    All Dogs Go to Heaven 2 (1996)
Name: Title, dtype: object
113    Wallace & Gromit: The Best of Aardman Animatio...
Name: Title, dtype: object
168    Wrong Trousers, The (1993)
Name: Title, dtype: object
188    Grand Day Out, A (1992)
Name: Title, dtype: object
```





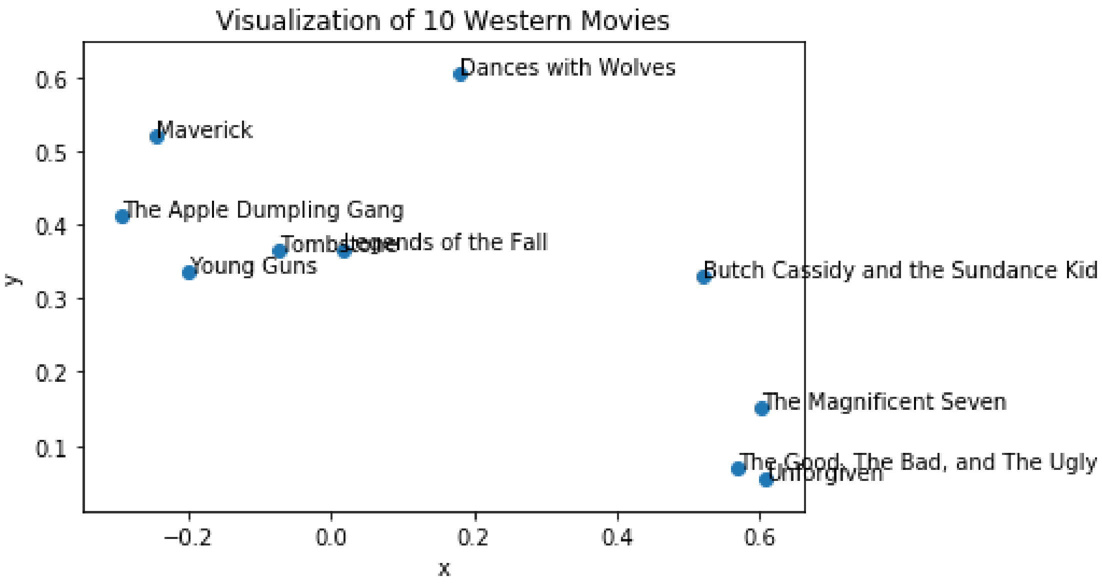


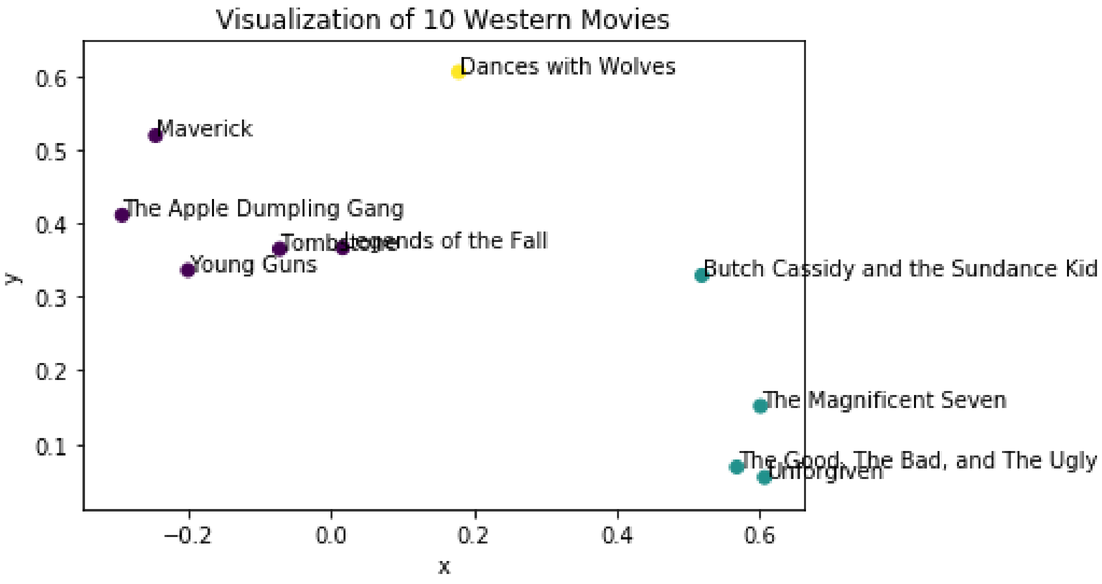
```
In [125]: # Visualize 10 Western movies
          # get all Western movies
```

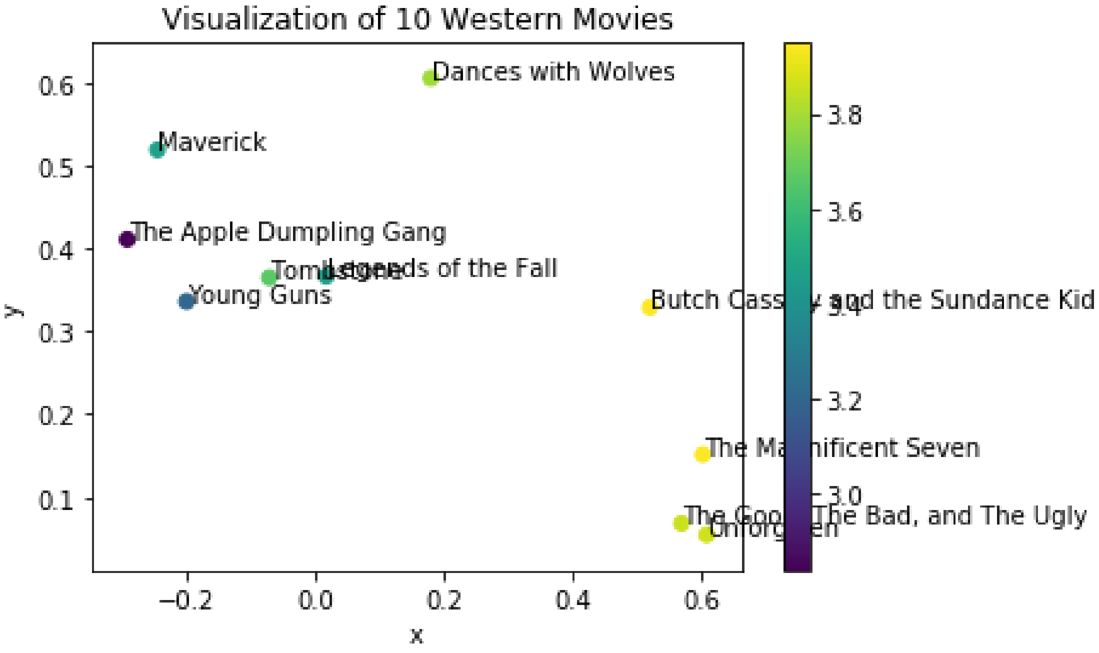
```
western = movies[movies['Western'] == 1]['ID'].head(10)

for i in western:
    print(movies[movies['ID'] == i]['Title'])

titles = ['Legends of the Fall', 'Maverick', 'Dances with Wolves', 'The Good, The Ba

x = [0]*10
y = [0]*10
count = 0

for i in western:
    x[count] = V_tilde[0][i-1]
    y[count] = V_tilde[1][i-1]
    count += 1

# clustering
X = np.column_stack((x, y))
labels = KMeans(n_clusters=3, random_state=0).fit_predict(X)

# plot visualization
fig, ax = plt.subplots()
plt.scatter(x, y)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Western Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.savefig('matrix_1_d_2.png')

# plot clusters
fig, ax = plt.subplots()
plt.scatter(x, y, c=labels)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Western Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.savefig('matrix_1_d_2_clusters.png')

# visualize movies by their average ratings
ratings = []
for i in western:
    ratings.append(movies['avg_rating'][i-1])
```

```
fig, ax = plt.subplots()
plt.scatter(x, y, c=ratings)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Western Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.colorbar()
plt.savefig('matrix_1_d_2_ratings.png')
```

```
50    Legends of the Fall (1994)
Name: Title, dtype: object
72    Maverick (1994)
Name: Title, dtype: object
96    Dances with Wolves (1990)
Name: Title, dtype: object
176    Good, The Bad and The Ugly, The (1966)
Name: Title, dtype: object
202    Unforgiven (1992)
Name: Title, dtype: object
231    Young Guns (1988)
Name: Title, dtype: object
411    Apple Dumpling Gang, The (1975)
Name: Title, dtype: object
431    Butch Cassidy and the Sundance Kid (1969)
Name: Title, dtype: object
466    Tombstone (1993)
Name: Title, dtype: object
505    Magnificent Seven, The (1954)
Name: Title, dtype: object
```


Visualization of 10 Western Movies
Dances with Wolves
Maverick
The Apple Dumpling Gang
Tombstone
Legends of the Fall
Young Guns
Butch Cassidy and the Sundance Kid
The Magnificent Seven
The Good, The Bad, and The Ugly
Unforgiven
0.6
0.5
0.4
0.3
0.2
0.1
y
−0.2
0.0
0.2
0.4
0.6
x


Visualization of 10 Western Movies
Dances with Wolves
Maverick
The Apple Dumpling Gang
Tombstone
Legends of the Fall
Young Guns
Butch Cassidy and the Sundance Kid
The Magnificent Seven
The Good, The Bad, and The Ugly
Unforgiven
0.6
0.5
0.4
0.3
0.2
0.1
y
−0.2
0.0
0.2
0.4
0.6
x

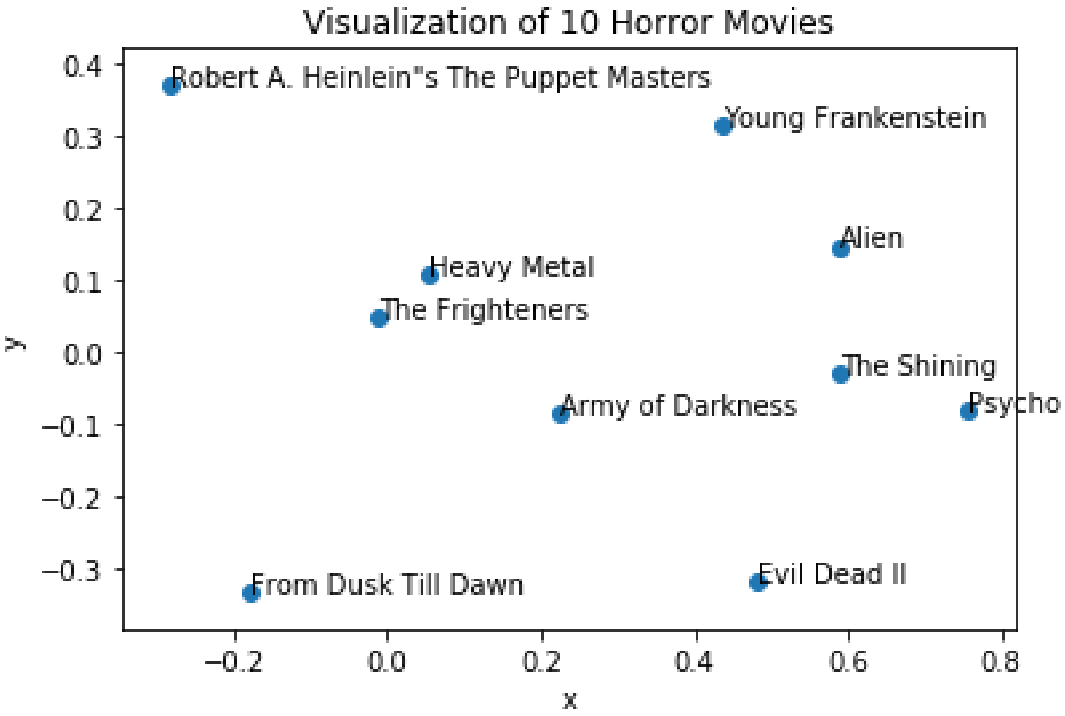


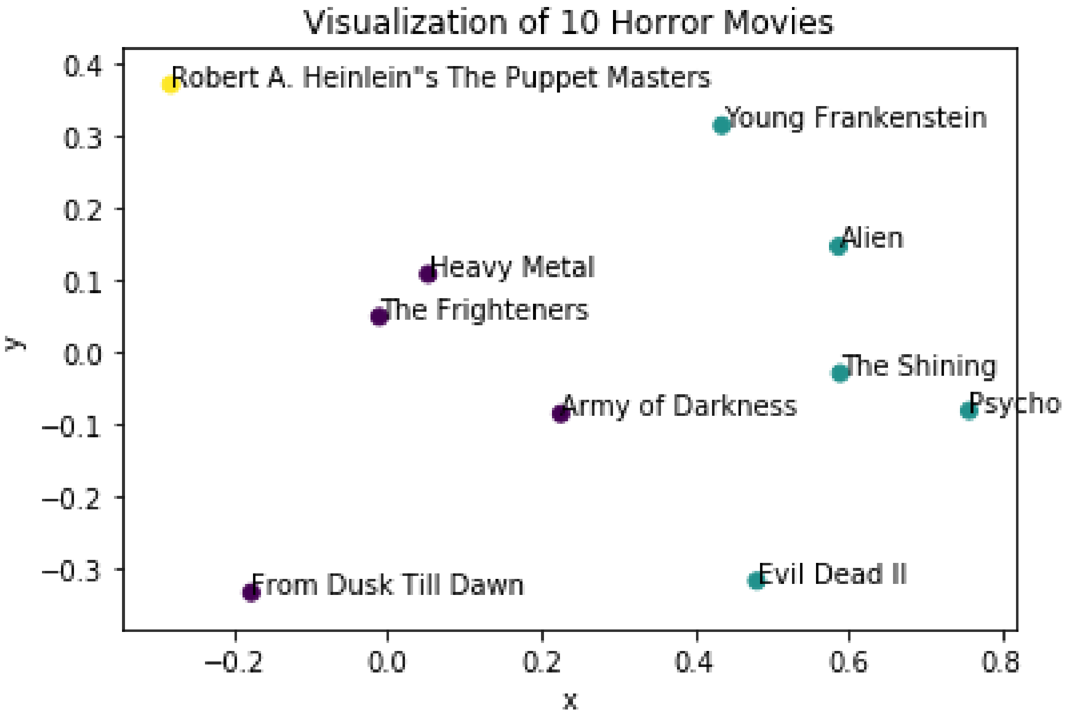
```
In [124]: # Visualize 10 horror movies
          horror = movies[movies['Horror'] == 1]['ID'].head(10)

          for i in horror:
              print(movies[movies['ID'] == i]['Title'])

          titles = ['From Dusk Till Dawn', 'Robert A. Heinlein"s The Puppet Masters', 'Heavy Me

          x = [0]*10
          y = [0]*10
          count = 0

          for i in horror:
              x[count] = V_tilde[0][i-1]
              y[count] = V_tilde[1][i-1]
              count += 1

          # clustering
          X = np.column_stack((x, y))
          labels = KMeans(n_clusters=3, random_state=0).fit_predict(X)

          # plot visualization
          fig, ax = plt.subplots()
          plt.scatter(x, y)
```

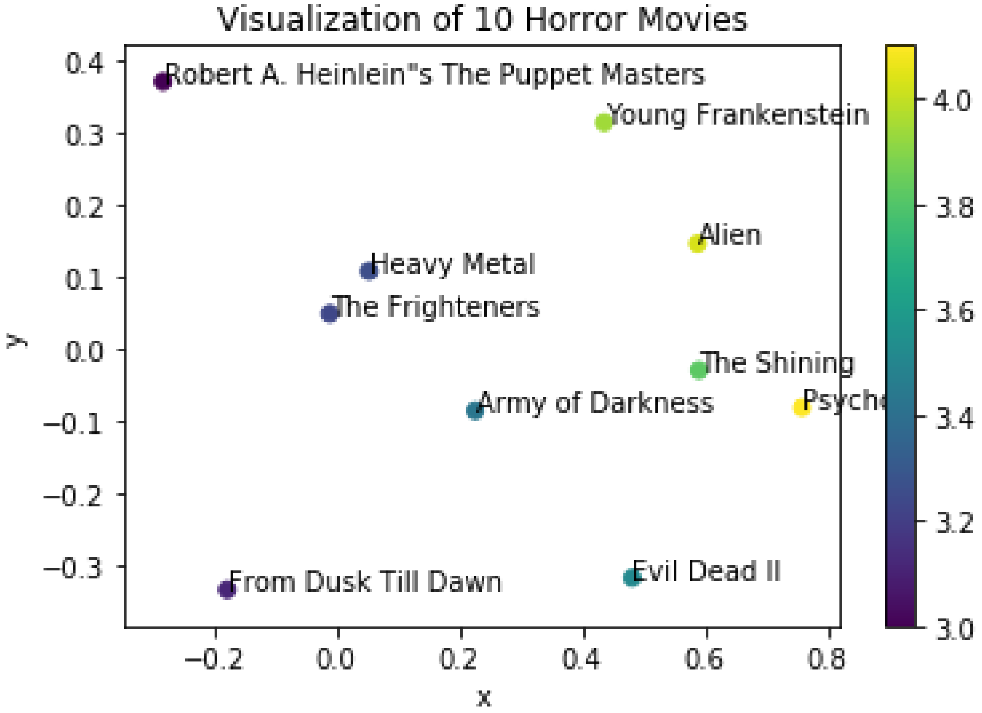
```
for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Horror Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.savefig('matrix_1_d_3_.png')

# plot clusters
fig, ax = plt.subplots()
plt.scatter(x, y, c=labels)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Horror Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.savefig('matrix_1_d_3_clusters.png')

# visualize movies by their average ratings
ratings = []
for i in horror:
    ratings.append(movies['avg_rating'][i-1])

fig, ax = plt.subplots()
plt.scatter(x, y, c=ratings)

for i, txt in enumerate(titles):
    ax.annotate(txt, (x[i], y[i]))

plt.title('Visualization of 10 Horror Movies')
plt.xlabel('x')
plt.ylabel('y')
plt.colorbar()
plt.savefig('matrix_1_d_3_ratings.png')
```

```
16    From Dusk Till Dawn (1996)
Name: Title, dtype: object
83    Robert A. Heinlein's The Puppet Masters (1994)
Name: Title, dtype: object
100    Heavy Metal (1981)
Name: Title, dtype: object
122    Frighteners, The (1996)
Name: Title, dtype: object
182    Alien (1979)
Name: Title, dtype: object
183    Army of Darkness (1993)
```

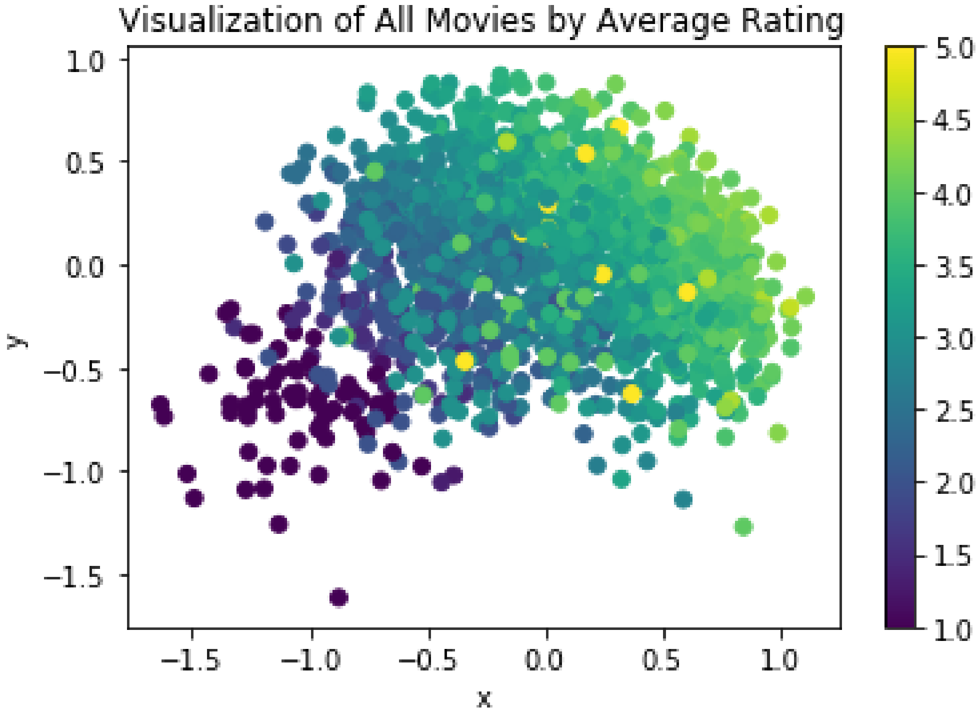
```
Name: Title, dtype: object
184    Psycho (1960)
Name: Title, dtype: object
199    Shining, The (1980)
Name: Title, dtype: object
200    Evil Dead II (1987)
Name: Title, dtype: object
207    Young Frankenstein (1974)
Name: Title, dtype: object
```




Visualization of 10 Horror Movies
Robert A. Heinlein"s The Puppet Masters
Young Frankenstein
Alien
Heavy Metal
The Frighteners
The Shining
Army of Darkness
Psycho
From Dusk Till Dawn
Evil Dead II
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
y
−0.2
0.0
0.2
0.4
0.6
0.8
x

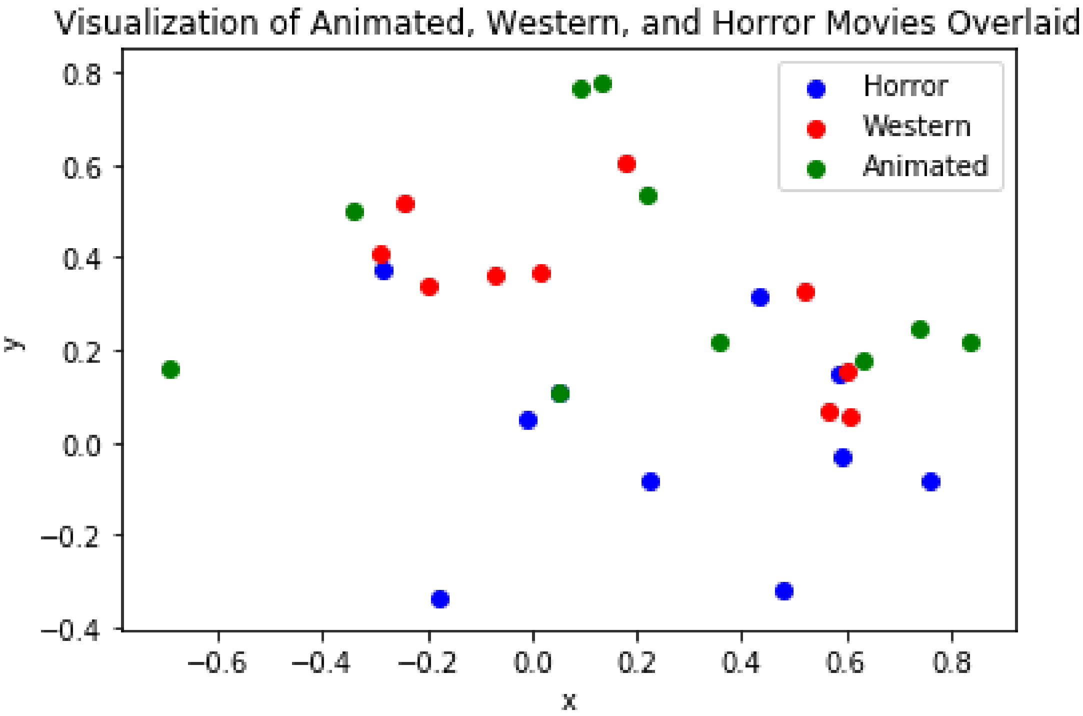

Visualization of 10 Horror Movies
Robert A. Heinlein"s The Puppet Masters
Young Frankenstein
Alien
Heavy Metal
The Frighteners
The Shining
Army of Darkness
Psycho
From Dusk Till Dawn
Evil Dead II
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
y
−0.2
0.0
0.2
0.4
0.6
0.8
x
4.0
3.8
3.6
3.4
3.2
3.0

```
In [142]: # visualization of all movies by average rating
          ratings = []
          for i in range(len(movies)):
              ratings.append(movies['avg_rating'][i])

          fig, ax = plt.subplots()
          plt.scatter(V_tilde[0], V_tilde[1], c=ratings)

          plt.title('Visualization of All Movies by Average Rating')
          plt.xlabel('x')
          plt.ylabel('y')
          plt.colorbar()
          plt.savefig('matrix_1_avg_rating.png')
```



```
In [145]: x = [0]*30
          y = [0]*30
          count = 0

          for i in horror:
              x[count] = V_tilde[0][i-1]
              y[count] = V_tilde[1][i-1]
              count += 1
          for i in western:
              x[count] = V_tilde[0][i-1]
```

```
        y[count] = V_tilde[1][i-1]
        count += 1
    for i in animated:
        x[count] = V_tilde[0][i-1]
        y[count] = V_tilde[1][i-1]
        count += 1

    fig, ax = plt.subplots()
    plt.scatter(x[:10], y[:10], c='b')
    plt.scatter(x[10:20], y[10:20], c='r')
    plt.scatter(x[20:30], y[20:30], c='g')

    plt.title('Visualization of Animated, Western, and Horror Movies Overlaid')
    plt.xlabel('x')
    plt.ylabel('y')
    plt.legend(['Horror', 'Western', 'Animated'])
    plt.savefig('matrix_1_genres.png')
```


Visualization of Animated, Western, and Horror Movies Overlaid
● Horror
● Western
● Animated
y
x