Clustering Assignment

There will be some functions that start with the word "grader" ex: grader_actors(), grader_movies(), grader_cost1() etc, you should not change those function definition.

Every Grader function has to return True.

Please check clustering assignment helper functions notebook before attempting this assignment.

- Read graph from the given movie_actor_network.csv (note that the graph is bipartite graph.)
- Using stellergaph and gensim packages, get the dense representation(128dimensional vector) of every node in the graph. [Refer Clustering_Assignment_Reference.ipynb]
- Split the dense representation into actor nodes, movies nodes.(Write you code in def data_split())

Task 1 : Apply clustering algorithm to group similar actors

1. For this task consider only the actor nodes
2. Apply any clustering algorithm of your choice
   Refer : https://scikit-learn.org/stable/modules/clustering.html
3. Choose the number of clusters for which you have maximum score of $Cost1 * Cost2$
4. Cost1 = $\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(number of nodes in the largest connected component in the graph with the actor nodes and its movie neighbours in cluster i)}}{\text{(total number of nodes in that cluster i)}}$ where N= number of clusters
   (Write your code in def cost1())
5. Cost2 = $\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(sum of degress of actor nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}{\text{(number of unique movie nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}$ where N= number of clusters
   (Write your code in def cost2())
6. Fit the clustering algorithm with the opimal number_of_clusters and get the cluster number for each node
7. Convert the d-dimensional dense vectors of nodes into 2-dimensional using dimensionality reduction techniques (preferably TSNE)
8. Plot the 2d scatter plot, with the node vectors after step e and give colors to nodes such that same cluster nodes will have same color

Task 2 : Apply clustering algorithm to group similar movies

1. For this task consider only the movie nodes
2. Apply any clustering algorithm of your choice 3.Choose the number of clusters for which you have maximum score of $Cost1 * Cost2$

   Cost1 = $\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(number of nodes in the largest connected component in the graph with the movie nodes and its actor neighbours in cluster i)}}{\text{(total number of nodes in that cluster i)}}$ where N= number of clusters
   (Write your code in def cost1())

3. Cost2 = $\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(sum of degress of movie nodes in the graph with the movie nodes and its actor neighbours in cluster i)}}{\text{(number of unique actor nodes in the graph with the movie nodes and its actor neighbours in cluster i)}}$ where N= number of clusters
   (Write your code in def cost2())

Algorithm for actor nodes

```
for number_of_clusters in [3, 5, 10, 30, 50, 100, 200, 500]:
    algo = clustering_algorith(clusters=number_of_clusters)
    # you will be passing a matrix of size N*d where N number of actor nodes and d is dimension from gensim
    algo.fit(the dense vectors of actor nodes)
    You can get the labels for corresponding actor nodes (algo.labels_)
    Create a graph for every cluster(ie., if n_clusters=3, create 3 graphs)
    (You can use ego_graph to create subgraph from the actual graph)
    compute cost1,cost2
       (if n_cluster=3, cost1=cost1(graph1)+cost1(graph2)+cost1(graph3) # here we are doing summation
        cost2=cost2(graph1)+cost2(graph2)+cost2(graph3)
    computer the metric Cost = Cost1*Cost2
return number_of_clusters which have maximum Cost
```

In [1]:
```python
#!pip install networkx==2.3
```

In [2]:
```python
#!pip install stellargraph
```

In [99]:
```python
%matplotlib inline
import networkx as nx
from networkx.algorithms import bipartite
import matplotlib.pyplot as plt
from sklearn.cluster import KMeans
import numpy as np
import warnings
warnings.filterwarnings("ignore")
import pandas as pd
# you need to have tensorflow
from stellargraph.data import UniformRandomMetaPathWalk
from stellargraph import StellarGraph
```

In [100…
```python
#data=pd.read_csv('movie_actor_network.csv', index_col=False, names=['movie','actor'])
```

For Google Colab

In [101…
```python
from google.colab import drive
drive.mount('/content/drive')
```

```
Drive already mounted at /content/drive; to attempt to forcibly remount, call drive.mount("/content/drive", force_remount=True).
```

In [102…
```python
data=pd.read_csv('/content/drive/MyDrive/14 Clustering on Graph Dataset/movie_actor_network.csv', index_col=False, names=['movie','actor'])
```

In [103…
```python
edges = [tuple(x) for x in data.values.tolist()]
```

In [104…
```python
B = nx.Graph()
B.add_nodes_from(data['movie'].unique(), bipartite=0, label='movie')
B.add_nodes_from(data['actor'].unique(), bipartite=1, label='actor')
B.add_edges_from(edges, label='acted')
```

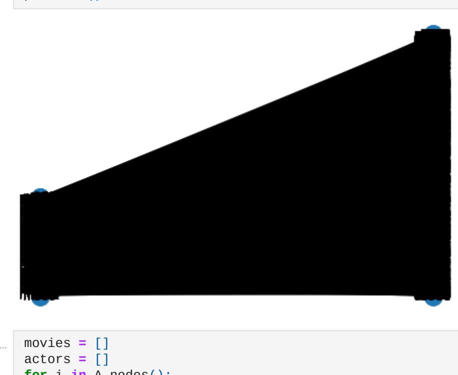
In [105…
```python
A = list(nx.connected_component_subgraphs(B))[0]
```

In [106…
```python
#A = (B.subgraph(c) for c in nx.connected_components(B))
#A = list(A)[0]
```

In [107…
```python
print("number of nodes", A.number_of_nodes())
print("number of edges", A.number_of_edges())
```

```
number of nodes 4703
number of edges 9650
```

In [108…
```python
l, r = nx.bipartite.sets(A)
pos = {}

pos.update((node, (1, index)) for index, node in enumerate(l))
pos.update((node, (2, index)) for index, node in enumerate(r))

nx.draw(A, pos=pos, with_labels=True)
plt.show()
```



In [109…
```python
movies = []
actors = []
for i in A.nodes():
    if 'm' in i:
        movies.append(i)
    if 'a' in i:
        actors.append(i)
print('number of movies ', len(movies))
print('number of actors ', len(actors))
```

```
number of movies  1292
number of actors  3411
```

In [110…
```python
# Create the random walker
rw = UniformRandomMetaPathWalk(StellarGraph(A))

# specify the metapath schemas as a list of lists of node types.
metapaths = [
    ["movie", "actor", "movie"],
    ["actor", "movie", "actor"]
]

walks = rw.run(nodes=list(A.nodes()), # root nodes
               length=100,  # maximum length of a random walk
               n=1,        # number of random walks per root node
               metapaths=metapaths
              )

print("Number of random walks: {}".format(len(walks)))
```

```
Number of random walks: 4703
```

In [111…
```python
from gensim.models import Word2Vec
model = Word2Vec(walks, size=128, window=5)
```

In [112…
```python
model.wv.vectors.shape  # 128-dimensional vector for each node in the graph
```

Out[112…
```
(4703, 128)
```

In [113…
```python
# Retrieve node embeddings and corresponding subjects
node_ids = model.wv.index2word  # list of node IDs
node_embeddings = model.wv.vectors  # numpy.ndarray of size number of nodes times embeddings dimensionality
node_targets = [ A.node[node_id]['label'] for node_id in node_ids]
```

```python
print(node_ids[:15], end='')
```

```
['a973', 'a967', 'a964', 'a1731', 'a969', 'a970', 'a1028', 'a1057', 'a965', 'a1003', 'm1094', 'a966', 'm67', 'a988', 'm1111']
```

```python
print(node_targets[:15],end='')
```

```
['actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'actor', 'movie', 'actor', 'movie', 'actor', 'movie']
```

In [114…
```python
def data_split(node_ids,node_targets,node_embeddings):
    '''In this function, we will split the node embeddings into actor_embeddings , movie_embeddings '''
    actor_nodes,movie_nodes=[],[]
    actor_embeddings,movie_embeddings=[],[]
    # split the node_embeddings into actor_embeddings,movie_embeddings based on node_ids
    # By using node_embedding and node_targets, we can extract actor_embedding and movie embedding
    # By using node_ids and node_targets, we can extract actor_nodes and movie nodes
    actor_nodes,movie_nodes=[],[]
    actor_embeddings,movie_embeddings=[],[]
    actor_target, movie_target = [], []

    for i in range(len(node_targets)):
      if node_targets[i] == 'actor':
        actor_nodes.append(node_ids[i])
        actor_embeddings.append(node_embeddings[i])
        actor_target.append(node_targets[i])
      else:
        movie_nodes.append(node_ids[i])
        movie_embeddings.append(node_embeddings[i])
        movie_target.append(node_targets[i])
    return actor_nodes,movie_nodes,actor_embeddings,movie_embeddings
```

In [115…
```python
actor_nodes,movie_nodes,actor_embeddings,movie_embeddings = data_split(node_ids,node_targets,node_embeddings)
```

Grader function - 1

In [116…
```python
def grader_actors(data):
    assert(len(data)==3411)
    return True
grader_actors(actor_nodes)
```

Out[116…
```
True
```

Grader function - 2

In [117…
```python
def grader_movies(data):
    assert(len(data)==1292)
    return True
grader_movies(movie_nodes)
```

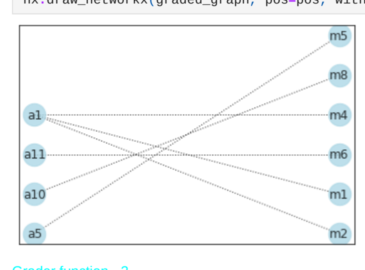
Out[117…
```
True
```

Calculating cost1

Cost1 = $\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(number of nodes in the largest connected component in the graph with the actor nodes and its movie neighbours in cluster i)}}{\text{(total number of nodes in that cluster i)}}$ where N= number of clusters

In [118…
```python
import operator as op
def cost1(graded_graph,k):
  actor_node_list = [i for i in graded_graph.node if 'a' in i]
  total_nodes_in_cluster = len(set(list(graded_graph.nodes())))
  nodewise_connected_ele = []
  for i in actor_node_list:
    selected_node_graph = nx.ego_graph(graded_graph, i)
    #print(selected_node_graph.nodes())
    connected_nodes = len(selected_node_graph.nodes())
    nodewise_connected_ele.append(len(selected_node_graph.nodes()))

  nodewise_connected_ele

  #Now select node with max xonnected components
  #print(dict(zip(actor_node_list, nodewise_connected_ele)))

  cluster_cost1 = op.truediv(max(nodewise_connected_ele),(total_nodes_in_cluster))
  cluster_cost1 = op.truediv(cluster_cost1 , k)

  return cluster_cost1
```

In [119…
```python
import networkx as nx
from networkx.algorithms import bipartite
graded_graph= nx.Graph()
graded_graph.add_nodes_from(['a1','a5','a10','a11'], bipartite=0) # Add the node attribute "bipartite"
graded_graph.add_nodes_from(['m1','m2','m4','m6','m5','m8'], bipartite=1)
graded_graph.add_edges_from([('a1','m1'),('a1','m2'),('a1','m4'),('a11','m6'),('a5','m5'),('a10','m8')])
l={'a1','a5','a10','a11'};r={'m1','m2','m4','m6','m5','m8'}
pos = {}
pos.update((node, (1, index)) for index, node in enumerate(l))
pos.update((node, (2, index)) for index, node in enumerate(r))
nx.draw_networkx(graded_graph, pos=pos, with_labels=True,node_color='lightblue',alpha=0.8,style='dotted',node_size=500)
```



Grader function - 3

In [120…
```python
graded_cost1=cost1(graded_graph,3)
def grader_cost1(data):
    assert(data==((1/3)*(4/10))) # 1/3 is number of clusters
    return True
grader_cost1(graded_cost1)
```

Out[120…
```
True
```

Calculating cost2

Cost2 = $\frac{1}{N}\sum_{\text{each cluster i}} \frac{\text{(sum of degress of actor nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}{\text{(number of unique movie nodes in the graph with the actor nodes and its movie neighbours in cluster i)}}$ where N= number of clusters

In [121…
```python
def cost2(graded_graph, k):

  '''In this function, we will calculate cost1'''

  #Select all the actor nodes from the actor data
  actor_node_list = [a for a in graded_graph.node if 'a' in a]

  #create Empty Graph
  cluster_graph=nx.Graph()

  #For each node in actor nodes, create ego graph and add node+edge info to cluster graph
  for i in actor_node_list:
    selected_node_graph = nx.ego_graph(graded_graph, i)
    cluster_graph.add_nodes_from(selected_node_graph.nodes())
    cluster_graph.add_edges_from(selected_node_graph.edges())

  #nx.draw(cluster_graph, with_labels = True)

  actor_node_list = [a for a in cluster_graph.node if 'a' in a]
  #print(actor_node_list)
  movie_node_list = [m for m in cluster_graph.node if 'm' in m]
  #print(movie_node_list)

  cluster_cost2 = op.truediv(len(list(cluster_graph.edges)),len(movie_node_list))
  cluster_cost2 = op.truediv(cluster_cost2 , k)

  return cluster_cost2
```

Grader function - 4

In [122…
```python
graded_cost2=cost2(graded_graph,3)
def grader_cost2(data):
    assert(data==((1/3)*(6/6))) # 1/3 is number of clusters
    return True
grader_cost2(graded_cost2)
```

Out[122…
```
True
```

Grouping similar actors

In [123…
```python
from tqdm import tqdm
k_list = [3, 5, 10, 30, 50, 100, 200, 500]

final_cost_list = []

#Selecting each value of k
for k in tqdm(k_list):
  K_means = KMeans(n_clusters=k, random_state=1, n_jobs=-1)
  K_means.fit(actor_embeddings)

  actor_df = pd.DataFrame(data=[actor_nodes] )
  actor_df = pd.DataFrame(actor_df.T)
  actor_df['actor_embeddings'] = actor_embeddings
  actor_df['cluster_no'] = list(K_means.labels_)
  actor_df.columns = ['actor_nodes', 'actor_embeddings', 'cluster_no']

  #HERE need to select all clusters one-by-one

  cluster_names = []
  for i in range(k):
    cluster_names.append(str('cluster_')+str(i))
  #cluster_names

  clusters_list = []
  for i in range(k):
    cluster_names[i] = pd.DataFrame(actor_df[actor_df.cluster_no==i])
    clusters_list.append(cluster_names[i])

  #select each cluster for all k
  for selected_cluster in clusters_list:
    cost1_list, cost2_list = [],[]

    #create Empty Graph
    selected_cluster_graph=nx.Graph()

    actor_node_list = list(selected_cluster.actor_nodes)

    #For each node in actor nodes, create ego graph and add node+edge info to cluster graph
    for i in actor_node_list:
      selected_node_graph = nx.ego_graph(A, i)
      selected_cluster_graph.add_nodes_from(selected_node_graph.nodes())
      selected_cluster_graph.add_edges_from(selected_node_graph.edges())

    #Visualizing Graph
    #nx.draw(selected_cluster_graph, with_labels=True)

    selected_cluster_cost1 = cost1(selected_cluster_graph, k)
    cost1_list.append(selected_cluster_cost1)

    selected_cluster_cost2 = cost2(selected_cluster_graph, k)
    cost2_list.append(selected_cluster_cost2)

  final_cost = sum(cost1_list) * sum(cost2_list)
  final_cost_list.append(final_cost)

k_cost = (dict(zip(k_list, final_cost_list)))
best_k = k_list[final_cost_list.index(max(final_cost_list))]
print("k = {0} gives max cost i.e. {1} ".format(best_k, max(final_cost_list)))
print(k_cost)
print("Best Value of k :", best_k)
```

```
100%|██████████| 8/8 [00:41<00:00,  5.13s/it]
k = 3 gives max cost i.e. 0.0935115093996007
{3: 0.0935115093996007, 5: 0.009967576515859552, 10: 0.015126085543119864, 30: 0.0005366789347756835, 50: 0.0004, 100: 0.0001, 200: 2.5e-05, 500: 2.653846153846154e-06}
Best Value of k : 3
```

Now train model with best K.

In [124…
```python
K_means = KMeans(n_clusters=best_k, random_state=1, n_jobs=-1)
K_means.fit(actor_embeddings)

actor_df = pd.DataFrame(data=[actor_nodes] )
actor_df = pd.DataFrame(actor_df.T)
#actor_df['actor_embeddings'] = actor_embeddings
actor_df['cluster_no'] = list(K_means.labels_)
actor_df.columns = ['actor_nodes', 'cluster_no']

actor_df
```

Out[124…

	actor_nodes	cluster_no
0	a973	2
1	a967	2
2	a964	2
3	a1731	2
4	a970	2
...	...	...
3406	a1990	1
3407	a1624	1
3408	a2152	1
3409	a1263	1
3410	a2023	1

3411 rows × 2 columns

Now the task is to display each cluster with different color.

Displaying similar actor clusters

In [125…
```python
from sklearn.manifold import TSNE
transform = TSNE #PCA

trans = transform(n_components=2)
actor_embeddings_2d = trans.fit_transform(actor_embeddings)
```

In [126…
```python
trial = pd.DataFrame(actor_embeddings_2d)
trial.columns = ['x', 'y']
trial['cluster_no'] = list(K_means.labels_)
trial
```

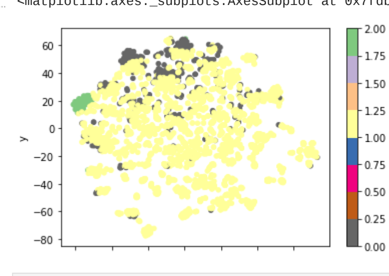
Out[126…

	x	y	cluster_no
0	-59.311085	15.375273	2
1	-58.056496	21.319038	2
2	-59.733837	15.557880	2
3	0.578625	64.590424	2
4	-59.396622	17.393166	2
...	...	...	...
3406	-22.048473	-3.789406	1
3407	-7.183355	25.884834	1
3408	-22.616083	-3.582985	1
3409	-7.055651	28.220812	1
3410	-12.539353	1.889613	1

3411 rows × 3 columns

In [127…
```python
trial.plot.scatter(x='x',
                   y='y',
                   c='cluster_no',
                   colormap='Accent_r')
```

Out[127…
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fdb38c52d90>
```



In [128…
```python
#Generating dataset for 3D Scatter Plot


'''trans = transform(n_components=3)
actor_embeddings_3d = trans.fit_transform(actor_embeddings)

trial_3D = pd.DataFrame(actor_embeddings_3d)
trial_3D.columns = ['D1', 'D2', 'D3']
trial_3D['cluster_no'] = list(K_means.labels_)


from google.colab import files
trial_3D.to_csv('actors_3D.csv')
files.download('actors_3D.csv')'''
```

Out[128…
```
"trans = transform(n_components=3)\nactor_embeddings_3d = trans.fit_transform(actor_embeddings)\n\ntrial_3D = pd.DataFrame(actor_embeddings_3d)\ntrial_3D.columns = ['D1', 'D2', 'D3']\ntrial_3D['cluster_no'] = list(K_means.labels_)\n\n\nfrom google.colab import files\ntrial_3D.to_csv('actors_3D.csv') \nfiles.download('actors_3D.csv')"
```

In [128…

Grouping similar movies

In [129…
```python
from tqdm import tqdm
k_list = [3, 5, 10, 30, 50, 100, 200, 500]

final_cost_list = []

#Selecting each value of k
for k in tqdm(k_list):
  K_means = KMeans(n_clusters=k, random_state=1, n_jobs=-1)
  K_means.fit(movie_embeddings)

  movie_df = pd.DataFrame(data=[movie_nodes] )
  movie_df = pd.DataFrame(movie_df.T)
  movie_df['movie_embeddings'] = movie_embeddings
  movie_df['cluster_no'] = list(K_means.labels_)
  movie_df.columns = ['movie_nodes', 'movie_embeddings', 'cluster_no']

  #HERE need to select all clusters one-by-one

  cluster_names = []
  for i in range(k):
    cluster_names.append(str('cluster_')+str(i))
  #cluster_names

  clusters_list = []
  for i in range(k):
    cluster_names[i] = pd.DataFrame(movie_df[movie_df.cluster_no==i])
    clusters_list.append(cluster_names[i])

  #select each cluster for all k
  for selected_cluster in clusters_list:
    cost1_list, cost2_list = [],[]

    #create Empty Graph
    selected_cluster_graph=nx.Graph()

    actor_node_list = list(selected_cluster.movie_nodes)

    #For each node in actor nodes, create ego graph and add node+edge info to cluster graph
    for i in actor_node_list:
      selected_node_graph = nx.ego_graph(A, i)
      selected_cluster_graph.add_nodes_from(selected_node_graph.nodes())
      selected_cluster_graph.add_edges_from(selected_node_graph.edges())

    #Visualizing Graph
    #nx.draw(selected_cluster_graph, with_labels=True)

    selected_cluster_cost1 = cost1(selected_cluster_graph, k)
    cost1_list.append(selected_cluster_cost1)

    selected_cluster_cost2 = cost2(selected_cluster_graph, k)
    cost2_list.append(selected_cluster_cost2)

  final_cost = sum(cost1_list) * sum(cost2_list)
  final_cost_list.append(final_cost)

k_cost = (dict(zip(k_list, final_cost_list)))
best_k = k_list[final_cost_list.index(max(final_cost_list))]
print("k = {0} gives max cost i.e. {1} ".format(best_k, max(final_cost_list)))
print(k_cost)
print("Best Value of k :", best_k)
```

```
100%|██████████| 8/8 [00:22<00:00,  2.84s/it]
k = 3 gives max cost i.e. 0.045617869313972444
{3: 0.045617869313972444, 5: 0.0437973116192195, 10: 0.001646831028749848, 30: 0.0014784205693296603, 50: 0.0007854545454545455, 100: 0.00019, 200: 4.615384615384615e-05, 500: 7.384615384615385e-06}
Best Value of k : 3
```

In [130…
```python
K_means = KMeans(n_clusters=best_k, random_state=1, n_jobs=-1)
K_means.fit(movie_embeddings)

movie_df = pd.DataFrame(data=[movie_nodes] )
movie_df = pd.DataFrame(movie_df.T)
#movie_df['movie_embeddings'] = movie_embeddings
movie_df['cluster_no'] = list(K_means.labels_)
movie_df.columns = ['movie_nodes', 'cluster_no']

movie_df
```

Out[130…

	movie_nodes	cluster_no
0	m1094	0
1	m1111	0
2	m1100	0
3	m67	0
4	m1095	0
...	...	...
1287	m48	1
1288	m33	1
1289	m251	1
1290	m1371	1
1291	m541	1

1292 rows × 2 columns

In [131…
```python
from sklearn.manifold import TSNE
transform = TSNE #PCA

trans = transform(n_components=2)
movie_embeddings_2d = trans.fit_transform(movie_embeddings)
```

In [132…
```python
trial = pd.DataFrame(movie_embeddings_2d)
trial.columns = ['x', 'y']
trial['cluster_no'] = list(K_means.labels_)
trial
```

Out[132…

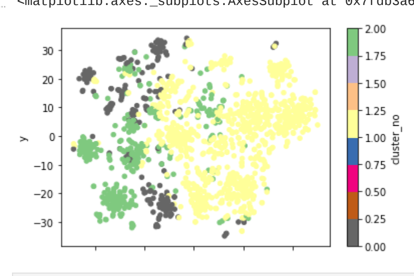
	x	y	cluster_no
0	-11.821812	32.679317	0
1	-27.674002	17.675865	0
2	-10.882120	28.317831	0
3	-20.846407	22.108248	0
4	-11.287133	29.356508	0
...	...	...	...
1287	-7.151497	-2.217743	1
1288	-8.996601	2.189119	1
1289	-3.274102	-0.734553	1
1290	-5.543108	-1.544203	1
1291	-4.023222	0.307190	1

1292 rows × 3 columns

Displaying similar movie clusters

In [133…
```python
trial.plot.scatter(x='x',
                   y='y',
                   c='cluster_no',
                   colormap='Accent_r')
```

Out[133…
```
<matplotlib.axes._subplots.AxesSubplot at 0x7fdb3a6e9cd0>
```



In [134…
```python
#Generating dataset for 3D Scatter Plot

'''trans = transform(n_components=3)
movie_embeddings_3d = trans.fit_transform(movie_embeddings)

movie_3D = pd.DataFrame(movie_embeddings_3d)
movie_3D.columns = ['D1', 'D2', 'D3']
movie_3D['cluster_no'] = list(K_means.labels_)


movie_3D.to_csv('movie_3D.csv')
files.download('movie_3D.csv')'''
```

Out[134…
```
"trans = transform(n_components=3)\nmovie_embeddings_3d = trans.fit_transform(movie_embeddings)\n\nmovie_3D = pd.DataFrame(movie_embeddings_3d)\nmovie_3D.columns = ['D1', 'D2', 'D3']\nmovie_3D['cluster_no'] = list(K_means.labels_)\n\n\nmovie_3D.to_csv('movie_3D.csv')\nfiles.download('movie_3D.csv')"
```