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.

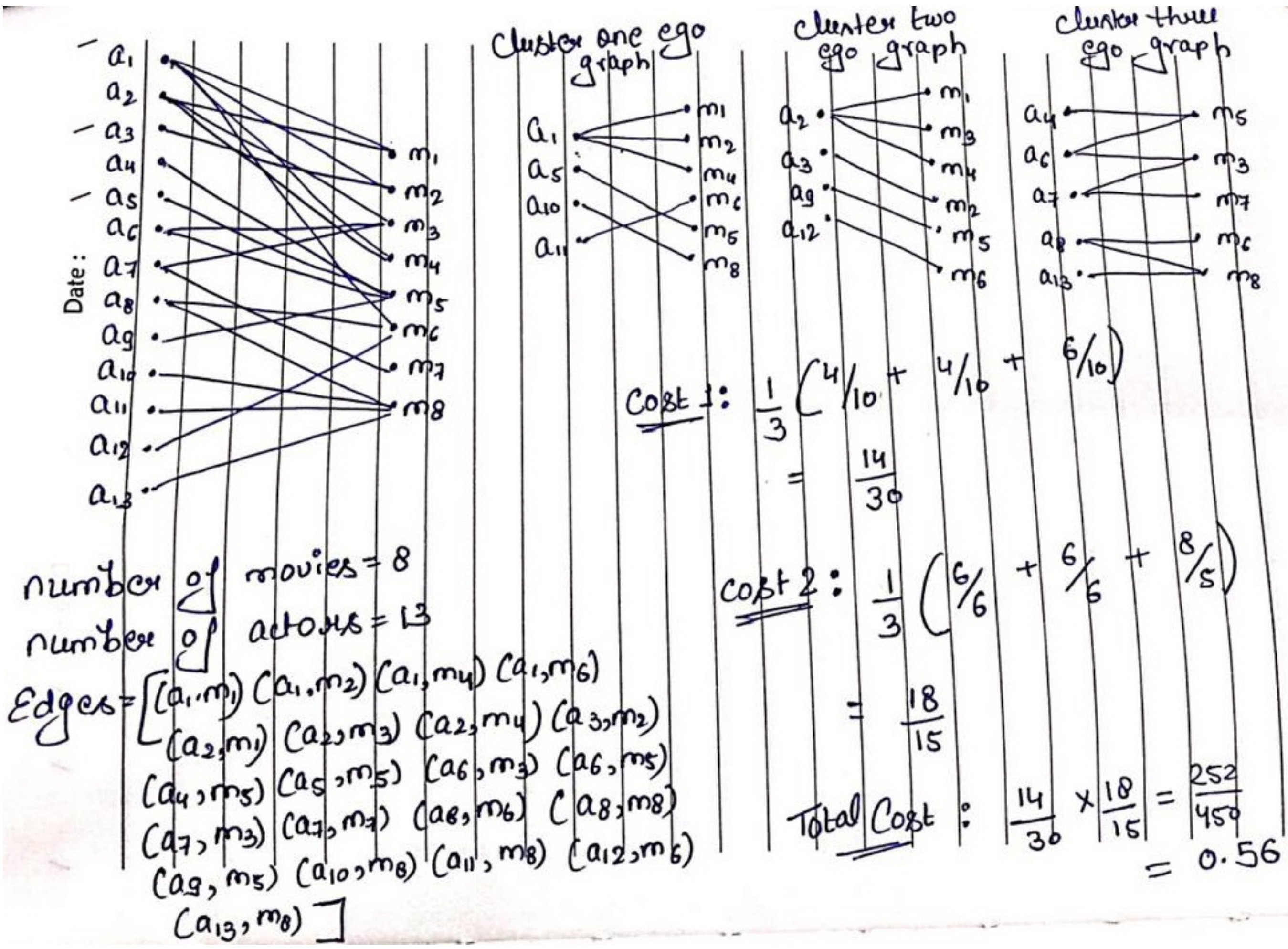
Every Grader function has to return True.

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 [5]:
```python
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
import matplotlib.pyplot as plt
```

In [6]:
```python
data=pd.read_csv('movie_actor_network.csv', index_col=False, names=['movie','actor'])
```

In [7]:
```python
edges = [tuple(x) for x in data.values.tolist()]
```

In [8]:
```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 [9]:
```python
#https://stackoverflow.com/questions/61154740/attributeerror-module-networkx-has-no-attribute-connected-component
A = (B.subgraph(c) for c in nx.connected_components(B))
A = list(A)[0]
```

In [10]:
```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 [ ]:
```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 [12]:

```
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 [13]:

```
# 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 [14]:

```
from gensim.models import Word2Vec
#https://stackoverflow.com/questions/53195906/getting-init-got-an-unexpected-keyword-argument-document-this-error
#Size is Changed as Vector_size
model = Word2Vec(walks, vector_size=128, window=5)
```

In [17]:

```
model.wv.vectors.shape  # 128-dimensional vector for each node in the graph
```

Out[17]:

```
(4703, 128)
```

In [18]:

```
# Retrieve node embeddings and corresponding subjects
node_ids = model.wv.index_to_key  # 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]
```

In [19]:

```
print(node_ids[:15])
```

```
['a973', 'a967', 'a964', 'a970', 'a1731', 'a969', 'a1028', 'a965', 'm1094', 'a1003', 'a1057', 'm1111', 'm1100', '
a966', 'a959']
```

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

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

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

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

In [20]:

```
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

    #split the Movie Embedding and Actor Embedding

    for node in range(len(node_ids)):
        #split the movie node
        if node_targets[node] == "actor":
            #append the actor nodes
            actor_nodes.append(node_ids[node])
            #add the vector for the corresponding Nodes
            actor_embeddings.append(node_embeddings[node])
        elif node_targets[node] == "movie":

            #add the movie nodes
            movie_nodes.append(node_ids[node])
             #add the vector for the corresponding movie Nodes
            movie_embeddings.append(node_embeddings[node])
        else:
            continue

    return actor_nodes,movie_nodes,actor_embeddings,movie_embeddings
```

In [21]:
```
print(type(node_ids))
```

```
<class 'list'>
```

In [22]:
```
actor_nodes,movie_nodes,actor_embeddings,movie_embeddings = data_split(node_ids,node_targets,node_embeddings)
```

In [23]:
```
print(len(actor_nodes))
```

```
3411
```

Grader function - 1

In [24]:
```
def grader_actors(data):
    assert(len(data)==3411)
    return True
grader_actors(actor_nodes)
```

Out[24]: True

Grader function - 2

In [25]:
```
def grader_movies(data):
    assert(len(data)==1292)
    return True
grader_movies(movie_nodes)
```

Out[25]: 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 [26]:
```
def cost1(graph,number_of_clusters):
    '''In this function, we will calculate cost1'''
    #https://networkx.org/documentation/stable/reference/algorithms/generated/networkx.algorithms.components.conn
    largest_component= max(nx.connected_components(graph), key=len)
    no_of_nodes =graph.number_of_nodes()
    #print(largest_component)
    cost = (1 /number_of_clusters) * (len(largest_component) / no_of_nodes)
```

```
    return cost
```

In [27]:

```
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_si
```

Grader function - 3

In [28]:

```
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[28]: 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 [29]:

```
def cost2(graph,number_of_clusters):
    '''In this function, we will calculate cost1'''
    movie_node = []
    nodes = graph.nodes()
    edges = graph.edges()
    for node in nodes:
        if node[0] == 'm':
            movie_node.append(node)

    cost= (1/number_of_clusters)*(len(edges)/len(movie_node))

    return cost
```

Grader function - 4

In [30]:

```
graded_graph.edges()
```

Out[30]: EdgeView([('a1', 'm1'), ('a1', 'm2'), ('a1', 'm4'), ('a5', 'm5'), ('a10', 'm8'), ('a11', 'm6')])

In [31]:

```
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[31]: True

In [32]:

```
def clustering_graph(no_of_cluster,nodes,vector_embedding,Movie_Actor_Node):


    """
        param - 1 -- no-of-cluster -> [1,2,5,9,100]

        param - 2 -- nodes (Movie Node or actor_node)

        param - 3 -- vector Embedding (dimention)-(n,128)

        param - 4 Movie_actor_node

    """
    cost_metrics_list =[]
```

```
    #iterate the cluster find the best cluster
    for clusters in no_of_cluster:
        #creater a cluster model
        cost1_cluster = 0.0
        cost2_cluster = 0.0

        #Kmeans Algorithm with cluster
        cluster_model = KMeans(n_clusters = clusters,random_state = 0, max_iter = 400)

        cluster_model.fit(vector_embedding)

        for cluster in range(clusters):
            #Create a Graph
            graph = nx.Graph()
            for node in range(len(nodes)):
                if (cluster_model.labels_[node] == cluster):
                    sub_graph = nx.ego_graph(Movie_Actor_Node,nodes[node])
                        #add eges from the graph
                    graph.add_edges_from(sub_graph.edges(data = True))

                    graph.add_nodes_from(sub_graph.nodes(data = True))
            #Compute the cost1 of of Each Cluster
            cost1_cluster += cost1(graph,clusters)
            #Computer the cost2 of Each Cluste
            cost2_cluster += cost2(graph,clusters)
        total_cost = cost1_cluster * cost2_cluster
        #add the cost at each stage
        cost_metrics_list.append(total_cost)

    #take the maximum cost from the list
    maximum_cost = max(cost_metrics_list)
    best_cluster = no_of_cluster[cost_metrics_list.index(maximum_cost)]

    print("Cost_Metrices : {0}".format(cost_metrics_list))
    return maximum_cost,best_cluster
```

In [33]:

```
print("Shape of Actor Embedding:{0}".format(np.array(actor_embeddings).shape))
```

```
Shape of Actor Embedding:(3411, 128)
```

In [34]:

```
#No of Cluster
no_of_clusters = [3, 5, 10, 30, 50, 100, 200, 500]
#Movie Nodes
maximum_cost,best_cluster = clustering_graph(no_of_clusters,actor_nodes,actor_embeddings,A)
```

```
Cost_Metrices : [3.743080863828378, 2.8525933240770365, 2.1381326771354208, 1.7527869914015346, 1.633515026895519
9, 1.803428202783101, 1.6588596608317416, 1.893577083154122]
```

In [35]:

```
print("Maximum Cost: {0}".format(maximum_cost))
print("Best K :{0}".format(best_cluster))
```

```
Maximum Cost: 3.743080863828378
Best K :3
```

Grouping and Visualize the Actor Cluster Using TSNE

In [36]:

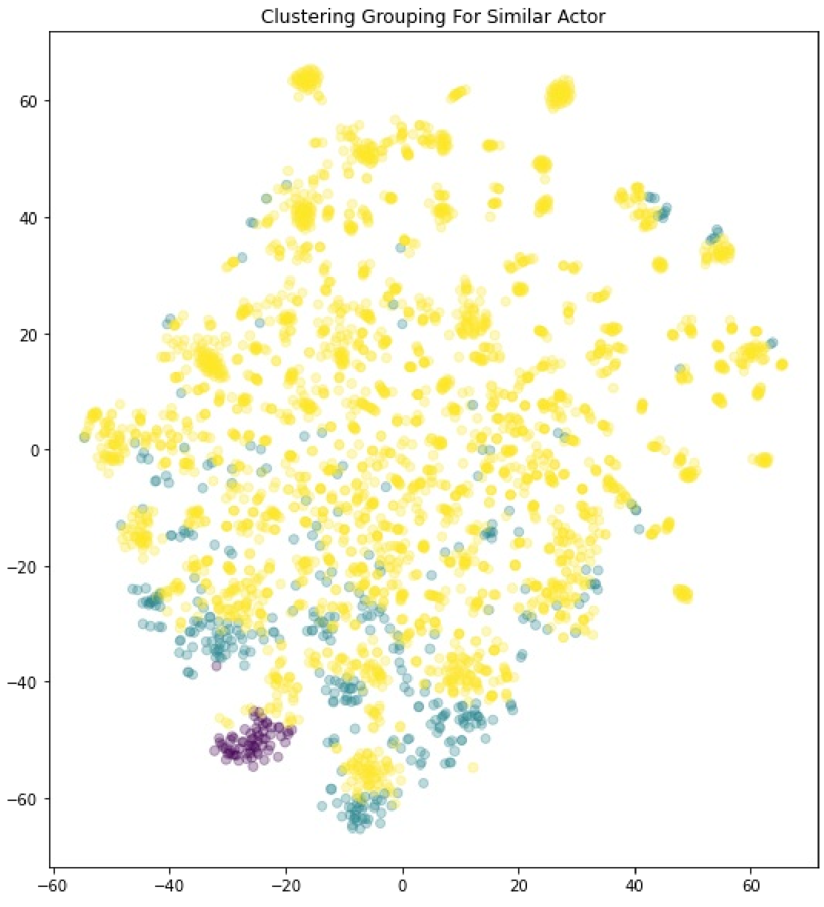
```
#Best K
from sklearn.manifold import TSNE
bestKmeans = KMeans(n_clusters = best_cluster,max_iter = 400,random_state = 0)
bestKmeans.fit(actor_embeddings)
tsne = TSNE(n_components=2,perplexity = 50,n_iter = 1500)
tsne = tsne.fit_transform(actor_embeddings)

label_map = { l: i for i, l in enumerate(bestKmeans.labels_)}
node_colours = [ label_map[target] for target in bestKmeans.labels_]
```

In [37]:

```
plt.figure(figsize=(10,10))
plt.axes().set(aspect="equal")
plt.scatter(tsne[:,0],
            tsne[:,1],
            c=node_colours, alpha=0.3)
plt.title('Clustering Grouping For Similar Actor')

plt.show()
```



Task - 2

In [41]:
```
#No of Cluster
no_of_clusters = [3, 5, 10, 30, 50, 100, 200, 500]
#Movie Nodes
maximum_cost_movie,best_cluster_movie = clustering_graph(no_of_clusters,movie_nodes,movie_embeddings,A)
```

```
Cost_Metrices : [8.49730978299386, 8.879555319268418, 9.030733204931922, 13.341233474482205, 13.012215112505643,
13.752493993617032, 12.620973423905482, 10.451868816764602]
```

In [42]:
```
print("Maximum Cost: {0}".format(maximum_cost))
print("Best K :{0}".format(best_cluster))
```

```
Maximum Cost: 13.752493993617032
Best K :100
```

In [43]:
```
print("Shape of Actor Embedding:{0}".format(np.array(movie_embeddings).shape))
```

```
Shape of Actor Embedding:(1292, 128)
```

Grouping and Visualize the Movie Cluster Using TSNE

In [44]:
```
#Best K
bestKmeans = KMeans(n_clusters = best_cluster,max_iter = 400,random_state = 0)
bestKmeans.fit(movie_embeddings)
tsne = TSNE(n_components=2,perplexity = 50,n_iter = 1500)
tsne = tsne.fit_transform(movie_embeddings)

label_map = { l: i for i, l in enumerate(bestKmeans.labels_)}
node_colours = [ label_map[target] for target in bestKmeans.labels_]

plt.figure(figsize=(10,10))
plt.axes().set(aspect="equal")
```

```
plt.scatter(tsne[:,0],
            tsne[:,1],
            c=node_colours, alpha=0.3)
plt.title('Clustering Grouping For Similar Movie')

plt.show()
```