CS5284 Graph Machine Learning

Coding sample

Instructions

Name: Please, add your name here : e.g. JOHN SMITH

Answers: Please write your answers directly in this notebook by completing the code sections marked with

`# YOUR CODE STARTS HERE`

`# YOUR CODE` (it can span one or multiple lines)

`# YOUR CODE ENDS HERE`.

Remark: If certain conditions of the questions (for eg. hyperparameter values) are not stated, you are free to choose anything you want.

Exercise : Graph Clustering with World Happiness Dataset

Import libraries and utility functions

In [1]:

```
%reset -f
import datetime
print('Timestamp:',datetime.datetime.now().strftime("%y-%m-%d--%H-%M-%S"))
import numpy as np
import scipy.sparse
import pandas as pd
import sklearn.metrics.pairwise
import networkx as nx
import sys; sys.path.insert(0, 'lib/')
from lib.utils import compute_ncut
from lib.utils import interactive_vis_graph
from lib.utils import print_neighboring_countries
from lib.utils import get_same_label_countries
```

```
Timestamp: 25-09-17--14-20-17
```

Load and visualize the dataset

In [2]:

```
wh = pd.read_csv("datasets/2019.csv") # load the dataset
# Features GDP per capita, Social support, Healthy life expectancy, Freedom to make life choices, Generosity, Perceptions of corruption
data = wh.iloc[:,3:].to_numpy()
print('Number of data points is', data.shape[0], 'and the number of features is', data.shape[1])
print('\nFirst three data points:\n', str(data[:3]))
print('\nData statistics:')
wh.describe()
```

```
Number of data points is 156 and the number of features is 6

First three data points:
 [[1.34  1.587 0.986 0.596 0.153 0.393]
 [1.383 1.573 0.996 0.592 0.252 0.41 ]
 [1.488 1.582 1.028 0.603 0.271 0.341]]

Data statistics:
```

Out[2]:

	Overall rank	Score	GDP per capita	Social support	Healthy life expectancy	Freedom to make life choices	Generosity	Perceptions of corruption
count	156.000000	156.000000	156.000000	156.000000	156.000000	156.000000	156.000000	156.000000
mean	78.500000	5.407096	0.905147	1.208814	0.725244	0.392571	0.184846	0.110603
std	45.177428	1.113120	0.398389	0.299191	0.242124	0.143289	0.095254	0.094538
min	1.000000	2.853000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
25%	39.750000	4.544500	0.602750	1.055750	0.547750	0.308000	0.108750	0.047000
50%	78.500000	5.379500	0.960000	1.271500	0.789000	0.417000	0.177500	0.085500
75%	117.250000	6.184500	1.232500	1.452500	0.881750	0.507250	0.248250	0.141250
max	156.000000	7.769000	1.684000	1.624000	1.141000	0.631000	0.566000	0.453000

Question 1 : Data normalization

Normalize the dataset `data` so that it has a mean of zero and a standard deviation of one along each data dimension.

After normalization, print both the mean and standard deviation of the normalized dataset.

Hint: You can use the functions `numpy.mean()` and `numpy.std()` for this task.

In [3]:

```
##############################
# Normalize the matrix data with zero mean and unit standard deviation
# YOUR CODE STARTS HERE
data = data - np.mean(data, axis=0)
data = data / np.std(data, axis=0)
print('data mean: ', np.mean(data, axis=0))
print('data std: ', np.std(data, axis=0))
# YOUR CODE ENDS HERE
##############################
```

```
data mean:  [-1.36642834e-16 -1.36642834e-16 -3.64380890e-16 -3.18833279e-16
  2.13504428e-16 -4.55476113e-17]
data std:  [1. 1. 1. 1. 1. 1.]
```

Question 2: Construct a k-nearest neighbors (kNN) graph

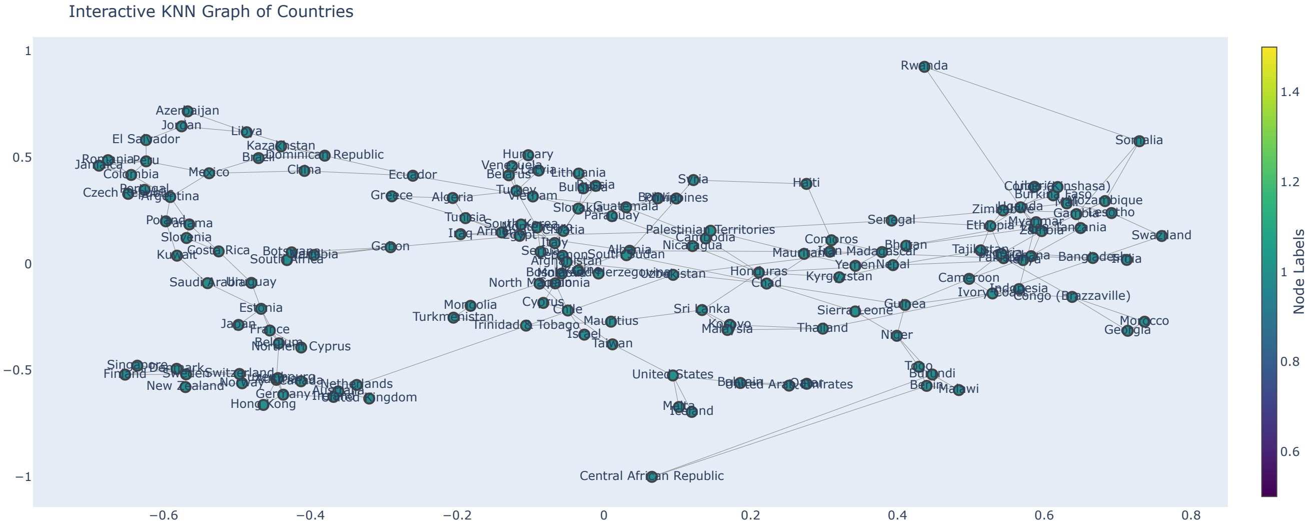
Follow the instructions below to construct a k-nearest neighbors (kNN) graph from the given dataset.

In [4]:

```
def construct_knn_graph(M, k):
    """Construct a graph using KNN
    Args:
        M: Data matrix as ndarray of size [n, d], n being the number of data points, d the number of features
        k: the number of nearest neighbors
    Return:
        A: Adjacency graph as scipy.sparse matrix of size [n, n]
    """

    # `dist_mat` is a n x n matrix with the pairwise distance between the data points
    dist_mat = sklearn.metrics.pairwise.pairwise_distances(M, metric='euclidean', n_jobs=1)
    dist_sorted = dist_mat.copy()
    ##############################
    # Instruction: Compute the n x k `dist_sorted` matrix, where each row contains the top k smallest distances for each data point.
    #              You may use function `numpy.sort()`.
    # YOUR CODE STARTS HERE
    dist_sorted = np.sort(dist_mat) # sort D from smallest to largest values
    dist_sorted = dist_sorted[:,:k]
    # YOUR CODE ENDS HERE
    ##############################

    # Adjacency matrix values `adj_val`
    sigma2 = np.mean(dist_sorted[:,-1])**2 # graph scale
    adj_val = np.exp(- dist_sorted**2 / sigma2)

    # Compute the n x n sparse adjacency matrix `A`
    n = M.shape[0]
    ##############################
    # Instruction: Compute the row and column indices, `row_idx` and `col_idx`, for each edge in the adjacency matrix.
    #              You may use functions `numpy.arange()` and `numpy.argsort()` and `numpy.reshape()`.
    # YOUR CODE STARTS HERE
    row_idx = np.arange(0, n).repeat(k)
    idx = np.argsort(dist_mat)[:,:k] # indices of k nearest neighbors
    col_idx = idx.reshape(n*k)
    # YOUR CODE ENDS HERE
    ##############################
    data = adj_val.reshape(n*k)
    A = scipy.sparse.csr_matrix((data, (row_idx, col_idx)), shape=(n, n))

    # Make A symmetric
    bigger = A.T > A
    A = A - A.multiply(bigger) + A.T.multiply(bigger)

    return A
```

In [5]:

```
# Construct the graph
A = construct_knn_graph(data, k=3)

# Visualize the graph of countries
countries = wh.iloc[:,1].values
labels = dict(zip(range(data.shape[0]), countries))
G_nx = nx.from_scipy_sparse_array(A)
G_nx.remove_edges_from(nx.selfloop_edges(G_nx)) # Remove self-loops
interactive_vis_graph(G_nx, countries, np.ones(data.shape[0]))
print_neighboring_countries(G_nx, countries, 'Finland')
print_neighboring_countries(G_nx, countries, 'Thailand')
print_neighboring_countries(G_nx, countries, 'Singapore')
```



```
Neighboring countries of Finland:
- Denmark
- Sweden
Neighboring countries of Thailand:
- Kosovo
- Malaysia
- Indonesia
Neighboring countries of Singapore:
- Denmark
- Sweden
```

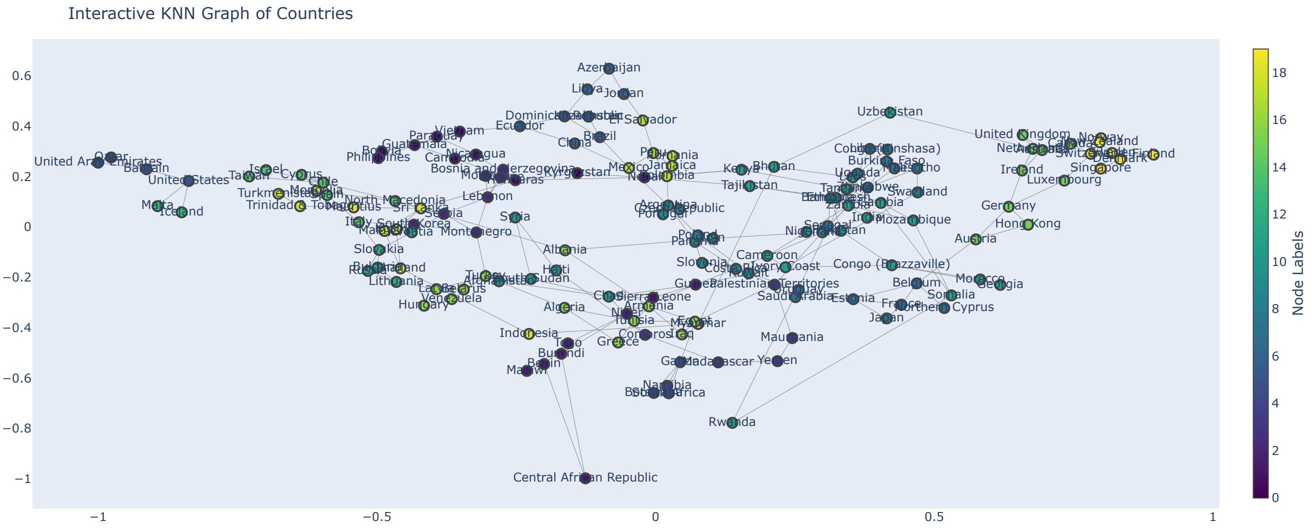
Question 3: Compute and visualize clusters of similar countries according to the features

Identify at least three countries that belong to the same cluster as Singapore.

Hint: Use the `get_same_label_countries(countries, C, 'Singapore')` function to display the countries in the same cluster as Singapore.

In [7]:

```
C, _ = compute_ncut(A, np.ones(data.shape[0]), 20)
interactive_vis_graph(G_nx, countries, C)
##############################
# YOUR CODE STARTS HERE
get_same_label_countries(countries, C, 'Singapore')
# YOUR CODE ENDS HERE
##############################
```



```
Countries in the same cluster as Singapore: ['Finland', 'Denmark', 'Norway', 'Switzerland', 'Sweden', 'New Zealand']
```

End of coding test

```
In [ ]:
```