Department of Computer Engineering

Academic Term: July-November 2023

Rubrics for Lab Experiments

Class : B.*E. Computer* **Subject Name :*BDA***
Semester : VII **Subject Code :**

Practical No:	9
Title:	Write a program to implement k-Means algorithm using any programming language.
Date of Performance:	26/09/2023
Roll No:	9427
Name of the Student:	Atharva Prashant Pawar

Evaluation:

Performance Indicator	Below average	Average	Good	Excellent	Marks
On time Submission (2)	Not submitted(0)	Submitted after deadline (1)	Early or on time submission(2)	---	
Test cases and output (4)	Incorrect output (1)	The expected output is verified only a for few test cases (2)	The expected output is Verified for all test cases but is not presentable (3)	Expected output is obtained for all test cases. Presentable and easy to follow (4)	
Coding efficiency (2)	The code is not structured at all (0)	The code is structured but not efficient (1)	The code is structured and efficient. (2)	-	
Knowledge(2)	Basic concepts not clear (0)	Understood the basic concepts (1)	Could explain the concept with suitable example (1.5)	Could relate the theory with real world application(2)	
Total					

Signature of the Teacher :

Importing libraries

```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
pd.options.display.float_format = '{:.2f}'.format

from sklearn.cluster import KMeans
from sklearn.metrics import silhouette_score
from mpl_toolkits.mplot3d import Axes3D

import plotly.express as px
# !pip install -U kaleido
import kaleido
```

Loading the dataset

```
dict_df = pd.read_csv("data-dictionary.csv")
data = pd.read_csv("Country-data.csv")
```

```
dict_df
```

	Column Name	Description
0	country	Name of the country
1	child_mort	Death of children under 5 years of age per 100...
2	exports	Exports of goods and services per capita. Give...
3	health	Total health spending per capita. Given as %ag...
4	imports	Imports of goods and services per capita. Give...
5	Income	Net income per person
6	Inflation	The measurement of the annual growth rate of t...
7	life_expec	The average number of years a new born child w...
8	total_fer	The number of children that would be born to e...
9	gdpp	The GDP per capita. Calculated as the Total GD...

```
data.head()
```

	country	child_mort	exports	health	imports	income	inflation	life_expec	total_fer	gdpp
0	Afghanistan	90.20	10.00	7.58	44.90	1610	9.44	56.20	5.82	553
1	Albania	16.60	28.00	6.55	48.60	9930	4.49	76.30	1.65	4090
2	Algeria	27.30	38.40	4.17	31.40	12900	16.10	76.50	2.89	4460
3	Angola	119.00	62.30	2.85	42.90	5900	22.40	60.10	6.16	3530
4	Antigua and Barbuda	10.30	45.50	6.03	58.90	19100	1.44	76.80	2.13	12200

EDA

```
data.shape
```

```
(167, 10)
```

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 167 entries, 0 to 166
Data columns (total 10 columns):
 #   Column      Non-Null Count  Dtype
---  ------      --------------  -----
 0   country     167 non-null    object
 1   child_mort  167 non-null    float64
 2   exports     167 non-null    float64
 3   health      167 non-null    float64
```

```
4   imports     167 non-null    float64
```

```
 5   income      167 non-null    int64  
 6   inflation   167 non-null    float64
 7   life_expec  167 non-null    float64
 8   total_fer   167 non-null    float64
 9   gdpp        167 non-null    int64  
dtypes: float64(7), int64(2), object(1)
memory usage: 13.2+ KB
```

```
data.describe()
```

	child_mort	exports	health	imports	income	inflation	life_expec	total_fer	gdpp
count	167.00	167.00	167.00	167.00	167.00	167.00	167.00	167.00	167.00
mean	38.27	41.11	6.82	46.89	17144.69	7.78	70.56	2.95	12964.16
std	40.33	27.41	2.75	24.21	19278.07	10.57	8.89	1.51	18328.70
min	2.60	0.11	1.81	0.07	609.00	-4.21	32.10	1.15	231.00
25%	8.25	23.80	4.92	30.20	3355.00	1.81	65.30	1.79	1330.00
50%	19.30	35.00	6.32	43.30	9960.00	5.39	73.10	2.41	4660.00
75%	62.10	51.35	8.60	58.75	22800.00	10.75	76.80	3.88	14050.00
max	208.00	200.00	17.90	174.00	125000.00	104.00	82.80	7.49	105000.00

```
data.isnull().sum()
```

```
country       0
child_mort    0
exports       0
health        0
imports       0
income        0
inflation     0
life_expec    0
total_fer     0
gdpp          0
dtype: int64
```

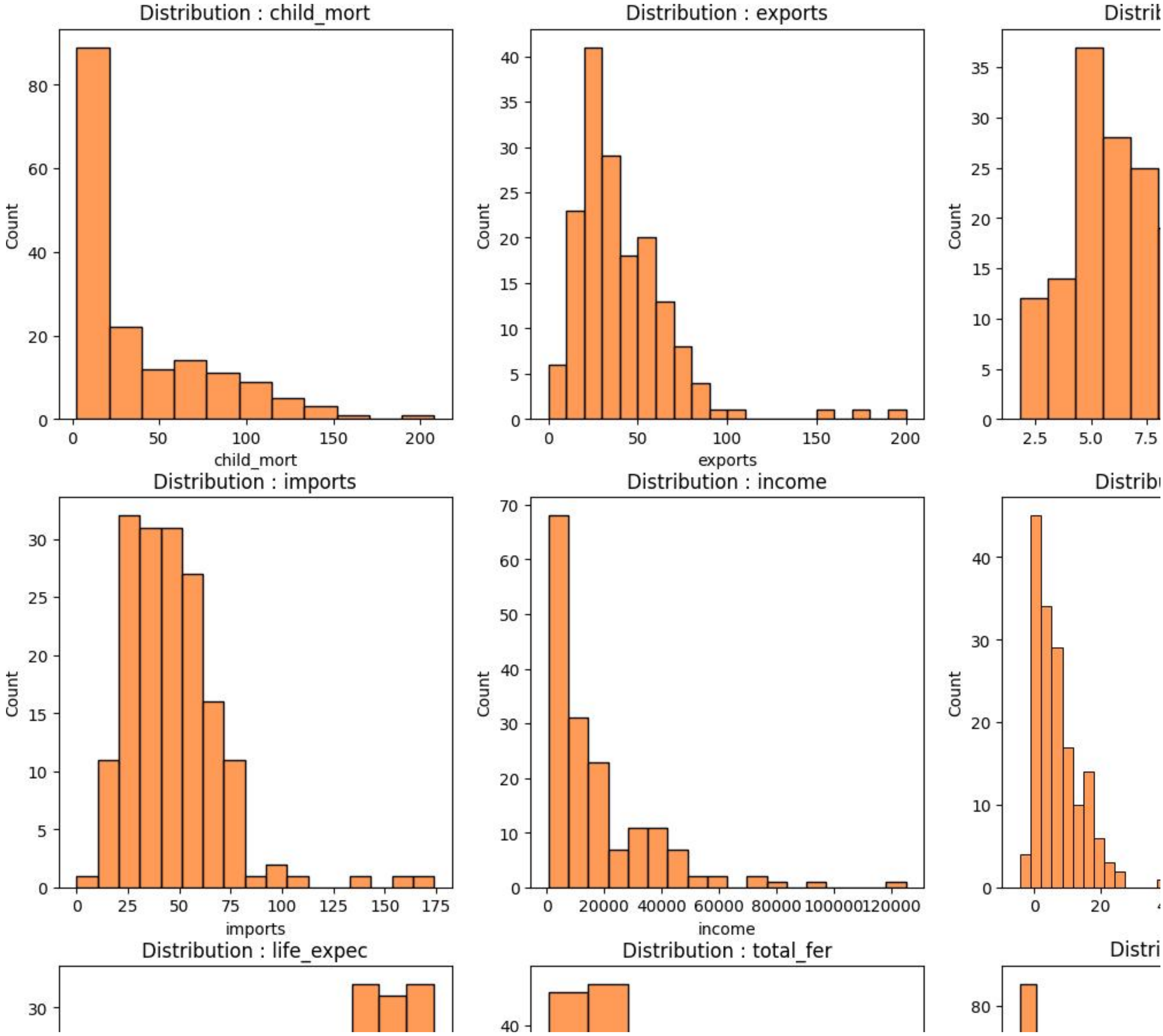
```
print("No of countries present: ",data['country'].nunique())
```

```
No of countries present:  167
```

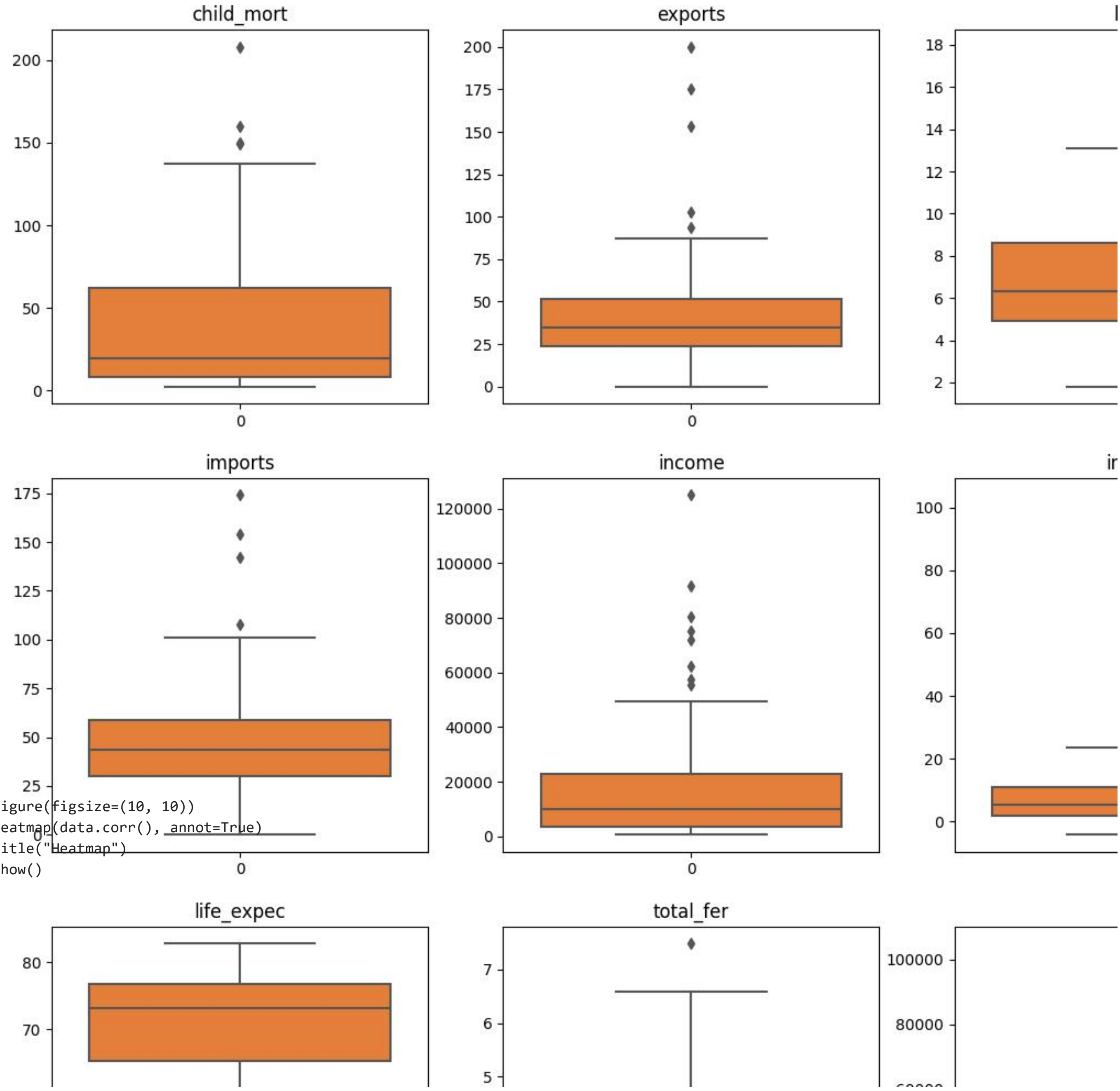
```
col = list(data.columns)
col.remove('country')
categorical_features = ['country']
numerical_features = [*col]
print('Categorical Features :',*categorical_features)
print('Numerical Features :',*numerical_features)
```

```
Categorical Features : country
Numerical Features : child_mort exports health imports income inflation life_expec total_fer gdpp
```

```
fig, ax = plt.subplots(nrows = 3,ncols = 3,figsize = (15,15))
colors = ['#FF781F','#2D2926']
for i in range(len(numerical_features)):
    plt.subplot(3,3,i+1)
    sns.histplot(data[numerical_features[i]],color = colors[0])
    title = 'Distribution : ' + numerical_features[i]
    plt.title(title)
plt.show()
```



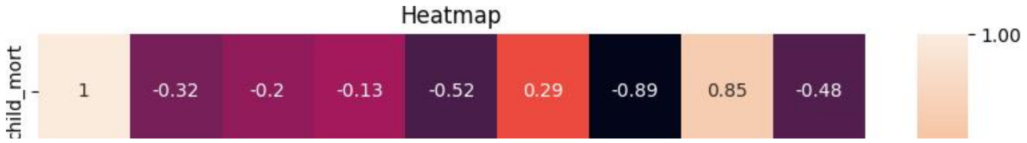
```
fig = plt.subplots(nrows = 3,ncols = 3,figsize = (15,15))
for i in range(len(numerical_features)):
    plt.subplot(3,3,i+1)
    ax = sns.boxplot(data=data[numerical_features[i]],color = colors[0])
    plt.title(numerical_features[i])
plt.show()
```



```
plt.figure(figsize=(10, 10))
sns.heatmap(data.corr(), annot=True)
plt.title("Heatmap")
plt.show()
```

```
<ipython-input-41-938d23771fea>:2: FutureWarning:

The default value of numeric_only in DataFrame.corr is deprecated. In a future version, it will default to False. Select only valid
```



```
df1 = pd.DataFrame()
df1['Health'] = (data['child_mort'] / data['child_mort'].mean()) + (data['health'] / data['health'].mean()) + (data['life_expec'] /
data[df1['Trade'] = (data['imports'] / data['imports'].mean()) + (data['exports'] / data['exports'].mean())
df1['Finance'] = (data['income'] / data['income'].mean()) + (data['inflation'] / data['inflation'].mean()) + (data['gdpp'] / data['gdpp']
df1.head()
```

	Health	Trade	Finance
0	6.24	1.20	1.35
1	3.04	1.72	1.47
2	3.39	1.60	3.17
3	6.47	2.43	3.49
4	2.96	2.36	2.24

```
from sklearn.preprocessing import MinMaxScaler,StandardScaler
mms = MinMaxScaler()
ss = StandardScaler()
df1['Health'] = mms.fit_transform(df1[['Health']])
df1['Trade'] = mms.fit_transform(df1[['Trade']])
df1['Finance'] = mms.fit_transform(df1[['Finance']])
df1.insert(loc = 0, value = list(data['country']), column = 'Country')
df1.head()
```

	Country	Health	Trade	Finance
0	Afghanistan	0.63	0.14	0.08
1	Albania	0.13	0.20	0.09
2	Algeria	0.18	0.19	0.21
3	Angola	0.66	0.28	0.24
4	Antigua and Barbuda	0.12	0.28	0.15

```
df2 = data.copy(deep = True)

col = list(data.columns)
col.remove('health'); col.remove('country')

df2['health'] = ss.fit_transform(df2[['health']]) # Standardization

for i in col:
    df2[i] = mms.fit_transform(df2[[i]]) # Normalization
df2.drop(columns = 'country',inplace = True)
df2.head()
```

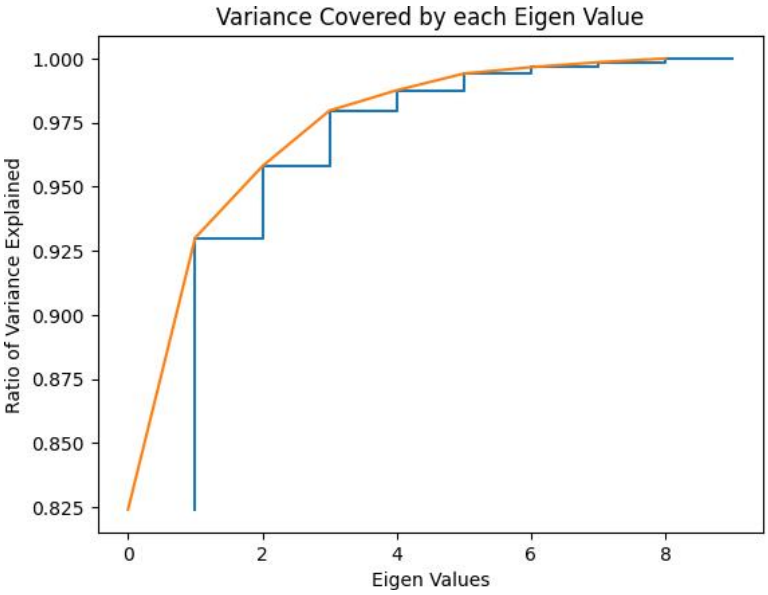
	child_mort	exports	health	imports	income	inflation	life_expec	total_fer	gdpp
0	0.43	0.05	0.28	0.26	0.01	0.13	0.48	0.74	0.00
1	0.07	0.14	-0.10	0.28	0.07	0.08	0.87	0.08	0.04
2	0.12	0.19	-0.97	0.18	0.10	0.19	0.88	0.27	0.04
3	0.57	0.31	-1.45	0.25	0.04	0.25	0.55	0.79	0.03
4	0.04	0.23	-0.29	0.34	0.15	0.05	0.88	0.15	0.11

```
from sklearn.decomposition import PCA

pca = PCA()
pca_df2 = pd.DataFrame(pca.fit_transform(df2))
pca.explained_variance_
```

```
array([1.01740511, 0.13090418, 0.03450018, 0.02679822, 0.00979752,
       0.00803398, 0.00307055, 0.00239976, 0.00179388])
```

```
plt.step(list(range(1,10)), np.cumsum(pca.explained_variance_ratio_))
plt.plot(np.cumsum(pca.explained_variance_ratio_))
plt.xlabel('Eigen Values')
plt.ylabel('Ratio of Variance Explained')
plt.title('Variance Covered by each Eigen Value')
plt.show()
```



```
pca_df2 = pca_df2.drop(columns = [3,4,5,6,7,8])
pca_df2.head()
```

	0	1	2
0	0.22	0.64	0.09
1	-0.08	-0.17	-0.21
2	-0.96	-0.13	-0.13
3	-1.51	0.47	0.28
4	-0.26	-0.24	-0.06

```
m1 = df1.drop(columns = ['Country']).values # Feature Combination : Health - Trade - Finance
m2 = pca_df2.values # PCA Data
```

```
sse = {};sil = [];kmax = 10
fig = plt.subplots(nrows = 1, ncols = 1, figsize = (20,5))

# Elbow Method :
plt.subplot(1,2,1)
for k in range(1, 10):
    kmeans = KMeans(n_clusters=k, max_iter=1000).fit(m1)
    sse[k] = kmeans.inertia_ # Inertia: Sum of distances of samples to their closest cluster center
sns.lineplot(x = list(sse.keys()), y = list(sse.values()));
plt.title('Elbow Method')
plt.xlabel("k : Number of cluster")
plt.ylabel("Sum of Squared Error")
plt.grid()
```

```
<ipython-input-49-4566498423fd>:5: MatplotlibDeprecationWarning:

Auto-removal of overlapping axes is deprecated since 3.6 and will be removed two minor releases later; explicitly call ax.remove() a

/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress the warning

/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress the warning

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```
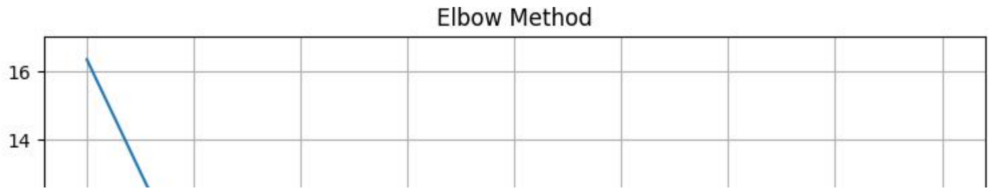
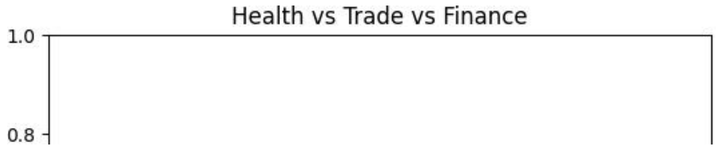
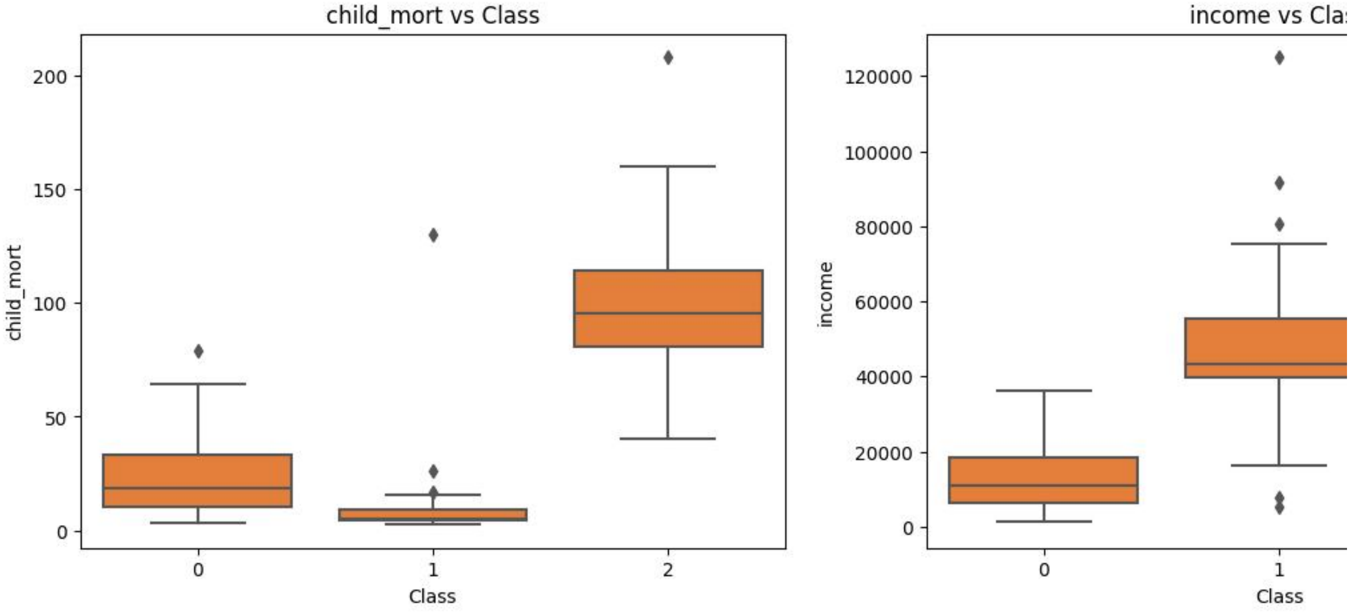



```
model = KMeans(n_clusters = 3,max_iter = 1000)
model.fit(m1)
cluster = model.cluster_centers_
centroids = np.array(cluster)
labels = model.labels_
data['Class'] = labels; df1['Class'] = labels

fig = plt.figure()
ax = Axes3D(fig)
x = np.array(df1['Health'])
y  =  np.array(df1['Trade'])
z = np.array(df1['Finance'])
ax.scatter(centroids[:,0],centroids[:,1],centroids[:,2],marker="X", color = 'b')
ax.scatter(x,y,z,c = y)
plt.title('Health vs Trade vs Finance')
ax.set_xlabel('Health')
ax.set_ylabel('Trade')
ax.set_zlabel('Finance')
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/cluster/_kmeans.py:870: FutureWarning:

The default value of `n_init` will change from 10 to 'auto' in 1.4. Set the value of `n_init` explicitly to suppress the warning
```



```
fig, ax = plt.subplots(nrows = 1, ncols = 2, figsize = (15,5))

plt.subplot(1,2,1)
sns.boxplot(x = 'Class', y = 'child_mort', data = data, color = '#FF781F');
plt.title('child_mort vs Class')

plt.subplot(1,2,2)
sns.boxplot(x = 'Class', y = 'income', data = data, color = '#FF781F');
plt.title('income vs Class')

plt.show()
```



From the above plot we can conclude :

0 : No Help

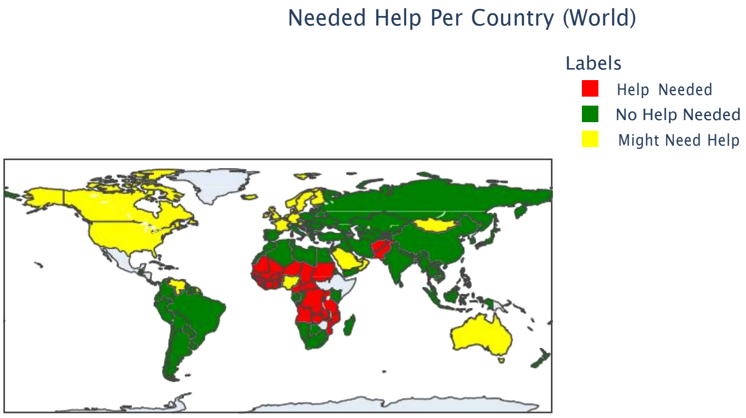
Needed 1 : Help

Needed

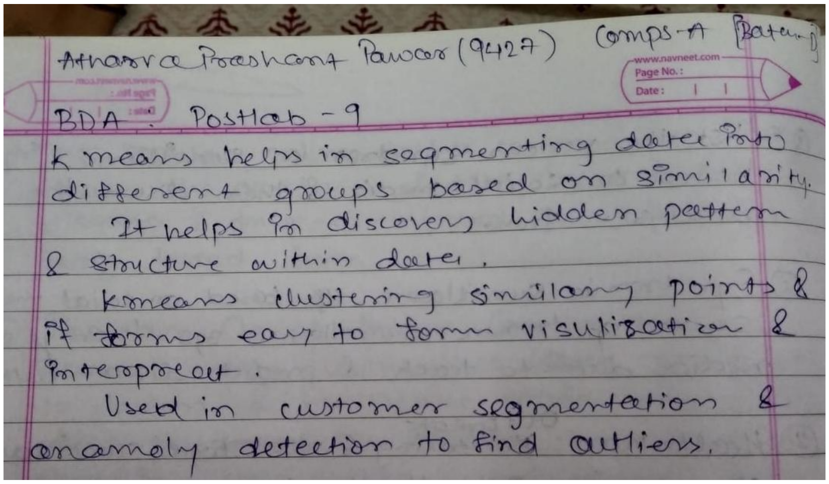
2 : Might Need Help

```
df1['Class'].loc[df1['Class'] == 0] = 'No Help Needed'
df1['Class'].loc[df1['Class'] == 1] = 'Help Needed'
df1['Class'].loc[df1['Class'] == 2] = 'Might Need Help'

fig = px.choropleth(df1[['Country','Class']],
                    locationmode = 'country names',
                    locations = 'Country',
                    title = 'Needed Help Per Country (World)',
                    color = df1['Class'],
                    color_discrete_map = {'Help Needed':'Red',
                                          'No Help Needed':'Green',
                                          'Might Need Help':'Yellow'}
                   )
fig.update_geos(fitbounds = "locations", visible = True)
fig.update_layout(legend_title_text = 'Labels',legend_title_side = 'top',title_pad_l = 260,title_y = 0.86)
fig.show(engine = 'kaleido')
```

```
<ipython-input-55-a313759b4d1f>:1: SettingWithCopyWarning:


A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
```



Postlab:



Atharva Prashant Pawar (9427) Comps-A [Batch-D]

BDA : Postlab - 9

k means helps in segmenting data into different groups based on similarity.

It helps in discovers hidden pattern & structure within data.

kmeans clustering similary points & it ~~forms~~ easy to form visulization & interpreat.

Used in customer segmentation & anamoly detection to find outliers.