```
# Importing Library
import numpy as np
import pandas as pd
import warnings
import pprint
import scipy.cluster.hierarchy
import matplotlib.pyplot as plt

warnings.filterwarnings('ignore')
warnings.warn('DelftStack')
warnings.warn('Do not show this message')
```

```
# Importing .csv File
dataset = pd.read_csv('USArrest.csv')
dataset_copy = pd.read_csv('USArrest.csv')
dataset_copy.drop(columns=['State'], inplace=True)
dataset.head()
```

	State	Murder	Assault	UrbanPop	Rape
0	Alabama	13.2	236	58	21.2
1	Alaska	10.0	263	48	44.5
2	Arizona	8.1	294	80	31.0
3	Arkansas	8.8	190	50	19.5
4	California	9.0	276	91	40.6

```
# Function to find Euclidean Distance
def euclideanDistance(point1, point2):
  return (np.sum((np.array(point1[1:]).astype('float')-np.array(point2[1:]).astype('
```

```
# Function to find Transformation
def transformation(cluster, clusterTranformed):
  for i in cluster:
    if type(i) == np.str_ or type(i) == float or type(i) == int or type(i) == str:
      clusterTranformed.append(cluster)
      break
    clusterTranformed = transformation(i, clusterTranformed)
  return clusterTranformed
```

```
# Function to find Minimum Distance
def minimumDistance(cluster1, cluster2):
  cluster1Transformed = transformation(cluster1, [])
  cluster2Transformed = transformation(cluster2, [])
  distances = [[abs(euclideanDistance(point1, point2)) for point2 in cluster2Transfo
```

```
  minDist = distances[0][0]
  for i in distances:
    for j in i:
      if minDist > j:
        minDist = j
  return minDist
```

```
# Function to find Maximum Distance
def maximumDistance(cluster1, cluster2):
  cluster1Transformed = transformation(cluster1, [])
  cluster2Transformed = transformation(cluster2, [])
  distances = [[abs(euclideanDistance(point1, point2)) for point2 in cluster2Transfo
  maxDist = distances[0][0]
  for i in distances:
    for j in i:
      if maxDist < j:
        maxDist = j
  return maxDist
```

```
# # Function to find Mean Distance
def meanDistance(cluster1, cluster2):
  cluster1Transformed = transformation(cluster1, [])
  cluster2Transformed = transformation(cluster2, [])
  mean1 = np.sum(np.array(cluster1Transformed)[:,1:].astype('float'), axis=0) / len(
  mean2 = np.sum(np.array(cluster2Transformed)[:,1:].astype('float'), axis=0) / len(
  meanDist = abs(euclideanDistance(mean1, mean2))
  return meanDist
```

```
# Function to find Average Distance
def averageDistance(cluster1, cluster2):
  cluster1Transformed = transformation(cluster1, [])
  cluster2Transformed = transformation(cluster2, [])
  distances = [[abs(euclideanDistance(point1, point2)) for point2 in cluster2Transfo
  averageDist = np.sum(distances) / (len(cluster1Transformed) * len(cluster2Transfor
  return averageDist
```

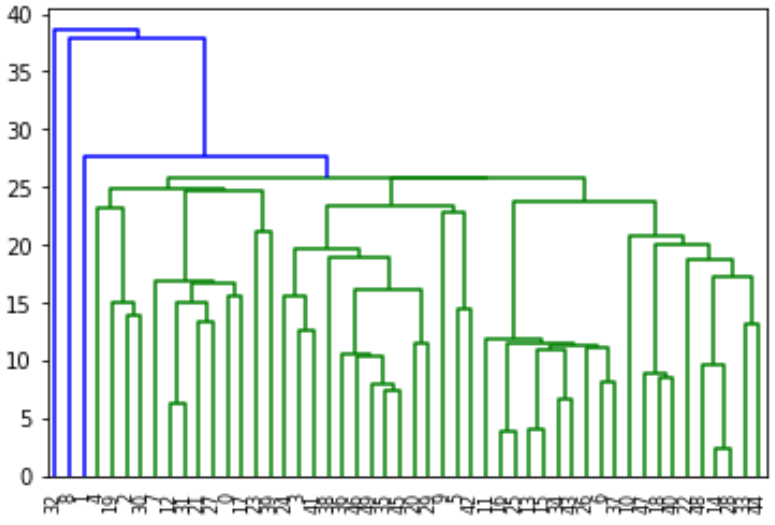
```
# Function for Agglomerative Clustering
def agglomerativeClustering(dataset, choiceOfDistance):
  functionOfDistance = None
  if choiceOfDistance == 1:
    functionOfDistance = minimumDistance
  elif choiceOfDistance == 2:
    functionOfDistance = maximumDistance
  elif choiceOfDistance == 3:
    functionOfDistance = meanDistance
  elif choiceOfDistance == 4:
    functionOfDistance = averageDistance
  numberOfIterations = len(dataset) - 1
```

```
  heirarchy = []
  clustersHeirarchy = dataset.to_numpy().tolist()
  statesHeirarchy = dataset['State'].to_numpy().tolist()
  for i in range(numberOfIterations):
    minimumDist = []
    for j in range(len(clustersHeirarchy)):
      for k in range(j+1, len(clustersHeirarchy)):
        distance = functionOfDistance(np.array(clustersHeirarchy[j]), np.array(clust
        if len(minimumDist) == 0:
          minimumDist.append(distance)
          minimumDist.append(clustersHeirarchy[j])
          minimumDist.append(clustersHeirarchy[k])
          minimumDist.append(statesHeirarchy[j])
          minimumDist.append(statesHeirarchy[k])
        else:
          if minimumDist[0] > distance:
            minimumDist.clear()
            minimumDist.append(distance)
            minimumDist.append(clustersHeirarchy[j])
            minimumDist.append(clustersHeirarchy[k])
            minimumDist.append(statesHeirarchy[j])
            minimumDist.append(statesHeirarchy[k])

    clustersHeirarchy.remove(minimumDist[1])
    clustersHeirarchy.remove(minimumDist[2])
    clustersHeirarchy.append([minimumDist[1], minimumDist[2]])

    statesHeirarchy.remove(minimumDist[3])
    statesHeirarchy.remove(minimumDist[4])
    statesHeirarchy.append([minimumDist[3], minimumDist[4]])

  return statesHeirarchy[0]
```

```
choicesOfDistance = ['Minimum Distance', 'Maximum Distance', 'Mean Distance', 'Avera
while(True):
  print('Different Types Of Distance Measures: ')
  print('\t1. Minimum Distance')
  print('\t2. Maximum Distance')
  print('\t3. Mean Distance')
  print('\t4. Average Distance\n')
  choiceOfDistance = int(input('Which Distance Measure do you want to use ? '))
  while(True):
    if choiceOfDistance > 0 and choiceOfDistance < 5:
      break
    else:
      print('Invalid Choice!\n')
      choiceOfDistance = int(input('Which Distance Measure do you want to use ? '))
  print(f'You have chosen "{choicesOfDistance[choiceOfDistance-1]}" measure')
  clustersHeirarchy = agglomerativeClustering(dataset, choiceOfDistance)
  print('\nHeirarchy:\n')
```

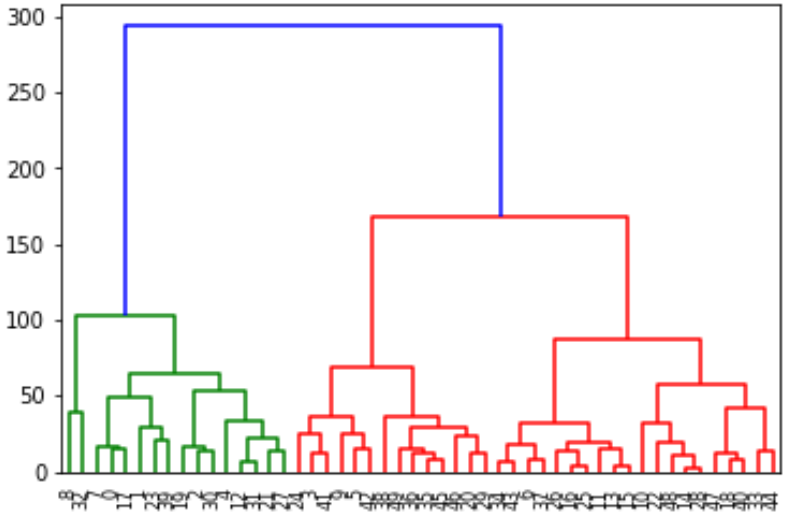
```
pprint.pprint(clustersHeirarchy, indent=3)
print('\nDendogram of the Clusters: ')
method = None
if choiceOfDistance == 1:
  method = 'single'
elif choiceOfDistance == 2:
  method = 'complete'
elif choiceOfDistance == 3:
  method = 'centroid'
else:
  method = 'average'
matrix = scipy.cluster.hierarchy.linkage(dataset_copy, method=method)
scipy.cluster.hierarchy.dendrogram(matrix)
plt.show()
toReExecute = input('\nDo you want to re-execute the algorithm ? (yes / no): ')
while(True):
  if toReExecute == 'yes':
    toReExecute = True
    break
  if toReExecute == 'no':
    toReExecute = False
    break
  else:
    print('Invalid Choice!\n')
    toReExecute = input('Which Distance Measure do you want to use ? (yes / no): '
print('\n-------------------------------------------------------------------------
if toReExecute:
  continue
else:
  break
```

```
Different Types Of Distance Measures:
        1. Minimum Distance
        2. Maximum Distance
        3. Mean Distance
        4. Average Distance

Which Distance Measure do you want to use ? 1
You have chosen "Minimum Distance" measure

Heirarchy:

[  'North Carolina',
   [  'Florida',
      [  'Alaska',
         [  [  ['California', ['Maryland', ['Arizona', 'New Mexico']]],
               [  [  'Delaware',
                     [  [['Illinois', 'New York'], ['Michigan', 'Nevada']],
                        ['Alabama', 'Louisiana']]],
                  ['Mississippi', 'South Carolina']]],
            [  [  [  ['Missouri', ['Arkansas', 'Tennessee']],
                     [  'Rhode Island',
                        [  [  'Oregon',
                              [  'Washington',
                                 ['Wyoming', ['Oklahoma', 'Virginia']]]],
                           ['Massachusetts', 'New Jersey']]]],
                  ['Georgia', ['Colorado', 'Texas']]],
               [  [  'Idaho',
                     [  ['Kentucky', 'Montana'],
                        [  [['Indiana', 'Kansas'], ['Ohio', 'Utah']],
                           ['Nebraska', ['Connecticut', 'Pennsylvania']]]]],
                  [  'Hawaii',
                     [  ['West Virginia', ['Maine', 'South Dakota']],
                        [  'Minnesota',
                           [  ['Wisconsin', ['Iowa', 'New Hampshire']],
                              ['North Dakota', 'Vermont']]]]]]]]]]]

Dendogram of the Clusters:
```



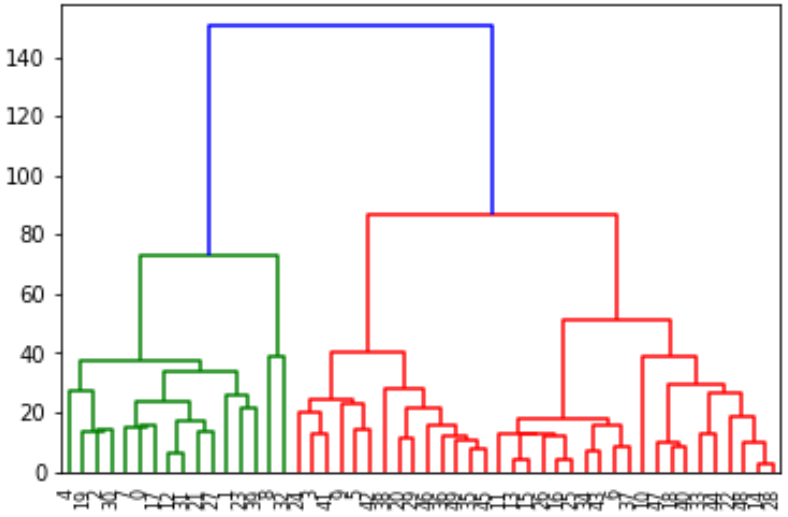

```
Do you want to re-execute the algorithm ? (yes / no): yes

------------------------------------------------------------------------------
```

```
Different Types Of Distance Measures:
        1. Minimum Distance
        2. Maximum Distance
        3. Mean Distance
        4. Average Distance

Which Distance Measure do you want to use ? 2
You have chosen "Maximum Distance" measure

Heirarchy:

[  [  ['Florida', 'North Carolina'],
      [  [  ['Delaware', ['Alabama', 'Louisiana']],
            ['Alaska', ['Mississippi', 'South Carolina']]],
         [  ['Maryland', ['Arizona', 'New Mexico']],
            [  'California',
               [['Illinois', 'New York'], ['Michigan', 'Nevada']]]]]],
   [  [  [  ['Missouri', ['Arkansas', 'Tennessee']],
            ['Georgia', ['Colorado', 'Texas']]],
         [  'Rhode Island',
            [  ['Wyoming', ['Oregon', ['Oklahoma', 'Virginia']]],
               ['Washington', ['Massachusetts', 'New Jersey']]]]],
      [  [  [['Ohio', 'Utah'], ['Connecticut', 'Pennsylvania']],
            [  ['Nebraska', ['Kentucky', 'Montana']],
               ['Idaho', ['Indiana', 'Kansas']]]],
         [  ['Hawaii', ['Minnesota', ['Wisconsin', ['Iowa', 'New Hampshire']]]
            [  ['West Virginia', ['Maine', 'South Dakota']],
               ['North Dakota', 'Vermont']]]]]]

Dendogram of the Clusters:
```




```
Do you want to re-execute the algorithm ? (yes / no): yes

------------------------------------------------------------------------------

Different Types Of Distance Measures:
        1. Minimum Distance
        2. Maximum Distance
        3. Mean Distance
        4. Average Distance
```

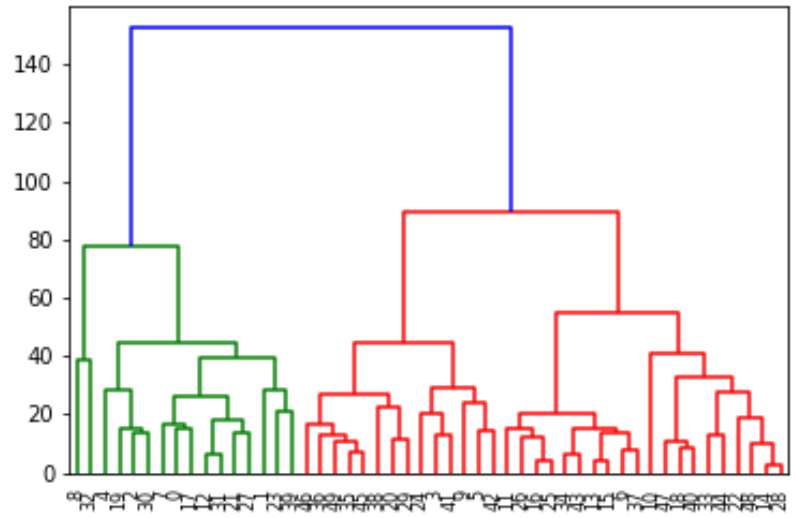
```
Which Distance Measure do you want to use ? 3
You have chosen "Mean Distance" measure

Heirarchy:

[  [  [  ['California', ['Maryland', ['Arizona', 'New Mexico']]],
         [  [  ['Alabama', ['Delaware', 'Louisiana']],
               [['Illinois', 'New York'], ['Michigan', 'Nevada']]],
            ['Alaska', ['Mississippi', 'South Carolina']]]],
      ['Florida', 'North Carolina']],
   [  [  [  ['Missouri', ['Arkansas', 'Tennessee']],
            ['Georgia', ['Colorado', 'Texas']]],
         [  'Rhode Island',
            [  ['Massachusetts', 'New Jersey'],
               [  'Washington',
                  ['Oregon', ['Wyoming', ['Oklahoma', 'Virginia']]]]]]],
      [  [  ['Idaho', ['Kentucky', 'Montana']],
            [  ['Ohio', 'Utah'],
               [  'Nebraska',
                  [['Indiana', 'Kansas'], ['Connecticut', 'Pennsylvania']]]]],
         [  'Hawaii',
            [  ['West Virginia', ['Maine', 'South Dakota']],
               [  ['North Dakota', 'Vermont'],
                  ['Minnesota', ['Wisconsin', ['Iowa', 'New Hampshire']]]]]]]]

Dendogram of the Clusters:
```




```
Do you want to re-execute the algorithm ? (yes / no): yes

------------------------------------------------------------------------------

Different Types Of Distance Measures:
        1. Minimum Distance
        2. Maximum Distance
        3. Mean Distance
        4. Average Distance

Which Distance Measure do you want to use ? 4
You have chosen "Average Distance" measure

Heirarchy:
```

```
[  [  ['Florida', 'North Carolina'],
      [  ['California', ['Maryland', ['Arizona', 'New Mexico']]],
         [  [  ['Delaware', ['Alabama', 'Louisiana']],
               [['Illinois', 'New York'], ['Michigan', 'Nevada']]],
            ['Alaska', ['Mississippi', 'South Carolina']]]]],
   [  [  [  ['Washington', ['Oregon', ['Wyoming', ['Oklahoma', 'Virginia']]]],
            ['Rhode Island', ['Massachusetts', 'New Jersey']]],
         [  ['Missouri', ['Arkansas', 'Tennessee']],
            ['Georgia', ['Colorado', 'Texas']]]],
      [  [  ['Idaho', ['Nebraska', ['Kentucky', 'Montana']]],
            [  ['Ohio', 'Utah'],
               [['Indiana', 'Kansas'], ['Connecticut', 'Pennsylvania']]]],
         [  'Hawaii',
            [  ['West Virginia', ['Maine', 'South Dakota']],
               [  ['North Dakota', 'Vermont'],
                  ['Minnesota', ['Wisconsin', ['Iowa', 'New Hampshire']]]]]]]]]
```

Dendogram of the Clusters:




```
Do you want to re-execute the algorithm ? (yes / no): no

------------------------------------------------------------------------------
```

✓ 47s completed at 22:16