220962050_Arhaan_Lab11

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0.1 Question

Consider the mentioned dataset and apply the hierarchical data-clustering algorithm, to identify the clusters. Write a Python function (without using the scikit-learn library) to do the following:-
a. Plot a graph that displays the number of clusters on the x-axis and the Sum of Squared Errors (SSE) on the y-axis.
b. Display the proximity matrix using Euclidean distance, Manhattan distance, and Minkowski distance.
c. Plot the dendrogram for single, complete, average, centroid, and ward linkage methods.

[8]:
```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
import scipy.cluster.hierarchy as sch
import scipy.spatial.distance as dist

data = np.array([
    [1, 1],    # p1
    [3, 2],    # p2
    [9, 1],    # p3
    [3, 7],    # p4
    [7, 2],    # p5
    [9, 7],    # p6
    [4, 8],    # p7
    [8, 3],    # p8
    [1, 4]     # p9
])
```

0.1.1 (B)

[9]:
```
def proximity_matrices(data):
    euclidean_dist = dist.squareform(dist.pdist(data, metric='euclidean'))
    manhattan_dist = dist.squareform(dist.pdist(data, metric='cityblock'))
    minkowski_dist = dist.squareform(dist.pdist(data, metric='minkowski', p=3))

    euclidean_df = pd.DataFrame(euclidean_dist, columns=[f'p{i+1}' for i in␣
 ↪range(len(data))],
                               index=[f'p{i+1}' for i in range(len(data))])
```

```
    manhattan_df = pd.DataFrame(manhattan_dist, columns=[f'p{i+1}' for i in␣
 ↪range(len(data))],
                                index=[f'p{i+1}' for i in range(len(data))])
    minkowski_df = pd.DataFrame(minkowski_dist, columns=[f'p{i+1}' for i in␣
 ↪range(len(data))],
                                index=[f'p{i+1}' for i in range(len(data))])

    return euclidean_df, manhattan_df, minkowski_df

euclidean_df, manhattan_df, minkowski_df = proximity_matrices(data)

print("Euclidean Distance Matrix:\n", euclidean_df)
print("\nManhattan Distance Matrix:\n", manhattan_df)
print("\nMinkowski Distance Matrix:\n", minkowski_df)
```

```
Euclidean Distance Matrix:
            p1        p2        p3        p4        p5         p6        p7  \
p1   0.000000  2.236068  8.000000  6.324555  6.082763  10.000000  7.615773
p2   2.236068  0.000000  6.082763  5.000000  4.000000   7.810250  6.082763
p3   8.000000  6.082763  0.000000  8.485281  2.236068   6.000000  8.602325
p4   6.324555  5.000000  8.485281  0.000000  6.403124   6.000000  1.414214
p5   6.082763  4.000000  2.236068  6.403124  0.000000   5.385165  6.708204
p6  10.000000  7.810250  6.000000  6.000000  5.385165   0.000000  5.099020
p7   7.615773  6.082763  8.602325  1.414214  6.708204   5.099020  0.000000
p8   7.280110  5.099020  2.236068  6.403124  1.414214   4.123106  6.403124
p9   3.000000  2.828427  8.544004  3.605551  6.324555   8.544004  5.000000

          p8        p9
p1  7.280110  3.000000
p2  5.099020  2.828427
p3  2.236068  8.544004
p4  6.403124  3.605551
p5  1.414214  6.324555
p6  4.123106  8.544004
p7  6.403124  5.000000
p8  0.000000  7.071068
p9  7.071068  0.000000

Manhattan Distance Matrix:
       p1    p2    p3    p4   p5    p6    p7   p8    p9
p1   0.0   3.0   8.0   8.0  7.0  14.0  10.0  9.0   3.0
p2   3.0   0.0   7.0   5.0  4.0  11.0   7.0  6.0   4.0
p3   8.0   7.0   0.0  12.0  3.0   6.0  12.0  3.0  11.0
p4   8.0   5.0  12.0   0.0  9.0   6.0   2.0  9.0   5.0
p5   7.0   4.0   3.0   9.0  0.0   7.0   9.0  2.0   8.0
p6  14.0  11.0   6.0   6.0  7.0   0.0   6.0  5.0  11.0
p7  10.0   7.0  12.0   2.0  9.0   6.0   0.0  9.0   7.0
```

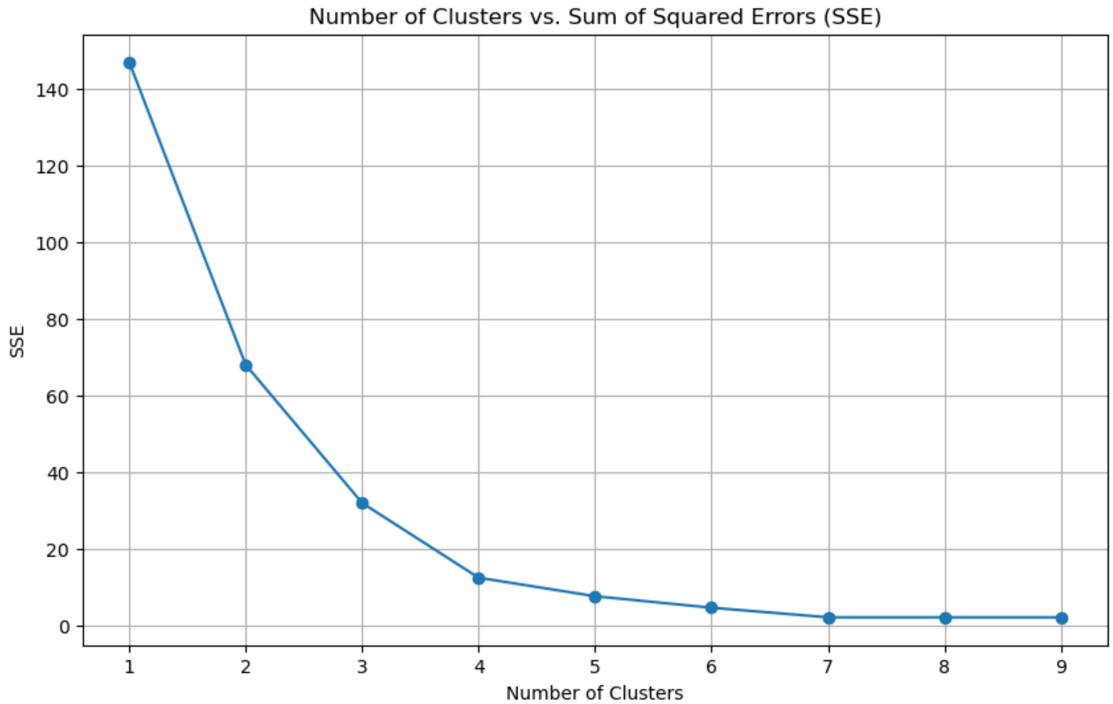
```
p8   9.0   6.0   3.0   9.0  2.0   5.0   9.0  0.0   8.0
p9   3.0   4.0  11.0   5.0  8.0  11.0   7.0  8.0   0.0

Minkowski Distance Matrix:
          p1        p2        p3        p4        p5        p6        p7  \
p1  0.000000  2.080084  8.000000  6.073178  6.009245  8.995883  7.179054
p2  2.080084  0.000000  6.009245  5.000000  4.000000  6.986368  6.009245
p3  8.000000  6.009245  0.000000  7.559526  2.080084  6.000000  7.763936
p4  6.073178  5.000000  7.559526  0.000000  5.738794  6.000000  1.259921
p5  6.009245  4.000000  2.080084  5.738794  0.000000  5.104469  6.240251
p6  8.995883  6.986368  6.000000  6.000000  5.104469  0.000000  5.013298
p7  7.179054  6.009245  7.763936  1.259921  6.240251  5.013298  0.000000
p8  7.054004  5.013298  2.080084  5.738794  1.259921  4.020726  5.738794
p9  3.000000  2.519842  8.138223  3.271066  6.073178  8.138223  4.497941

          p8        p9
p1  7.054004  3.000000
p2  5.013298  2.519842
p3  2.080084  8.138223
p4  5.738794  3.271066
p5  1.259921  6.073178
p6  4.020726  8.138223
p7  5.738794  4.497941
p8  0.000000  7.006796
p9  7.006796  0.000000
```

0.1.2 (A)

[10]:
```python
def calculate_sse(data, clusters):
    sse = 0
    for cluster in clusters:
        cluster_points = data[cluster]
        cluster_center = np.mean(cluster_points, axis=0)
        sse += np.sum((cluster_points - cluster_center) ** 2)
    return sse

def plot_sse(data):
    sse_values = []
    for k in range(1, len(data) + 1):
        linkage_matrix = sch.linkage(data, method='ward')
        clusters = sch.fcluster(linkage_matrix, k, criterion='maxclust')
        sse = calculate_sse(data, [np.where(clusters == i)[0] for i in range(1, 
 ↪k + 1)])
        sse_values.append(sse)

    plt.figure(figsize=(10, 6))
    plt.plot(range(1, len(data) + 1), sse_values, marker='o')
```

```
    plt.title('Number of Clusters vs. Sum of Squared Errors (SSE)')
    plt.xlabel('Number of Clusters')
    plt.ylabel('SSE')
    plt.grid(True)
    plt.show()

plot_sse(data)
```

```
/usr/lib/python3/dist-packages/numpy/core/fromnumeric.py:3504: RuntimeWarning:
Mean of empty slice.
  return _methods._mean(a, axis=axis, dtype=dtype,
/usr/lib/python3/dist-packages/numpy/core/_methods.py:121: RuntimeWarning:
invalid value encountered in divide
  ret = um.true_divide(
```



0.1.3 (C)

[11]:
```
def plot_dendrogram(data):
    methods = ['single', 'complete', 'average', 'centroid', 'ward']

    plt.figure(figsize=(15, 10))
    for i, method in enumerate(methods):
        plt.subplot(3, 2, i + 1)
        linkage_matrix = sch.linkage(data, method=method)
```

```
        sch.dendrogram(linkage_matrix)
        plt.title(f'Dendrogram ({method.capitalize()} Linkage)')
        plt.xlabel('Sample Index')
        plt.ylabel('Distance')

    plt.tight_layout()
    plt.show()

plot_dendrogram(data)
```