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ALDA CSC 522 HW4

Q1

Import libraries

```
import numpy as np
import pandas as pd
from copy import deepcopy
import matplotlib.pyplot as plt
from scipy.spatial import distance
%matplotlib inline
```

Helper Functions

```
# Helper function to draw scatter plot
def scatter_plot(data, centroids, clusters):
    figure = plt.figure(figsize=(8,8))
    plt.scatter(data[:,0], data[:,1], color='b')
    colors_map = ['blue', 'green', 'red','black']
    plt.xlim(0, 10)
    plt.ylim(0, 10)
    for i, text in enumerate(data_labels):
        plt.annotate(text, (data[i,0]*(1.04), data[i,1]*(1.04)), fontsize =
14)
    for i in range(k):
        plt.scatter(centroids[i,0], centroids[i,1], marker='*',
color=colors_map[i], s=250)
    for i in range(n):
        plt.scatter(data[i,0], data[i,1],color=colors_map[clusters[i]])
    plt.grid(which='both', linestyle='dotted')
    plt.show()
```

```
data = np.array([[1,8], [1,1], [2,4], [3,3], [4,9], [4,6], [6,4], [7,7],
[9,9], [9,1]])
```

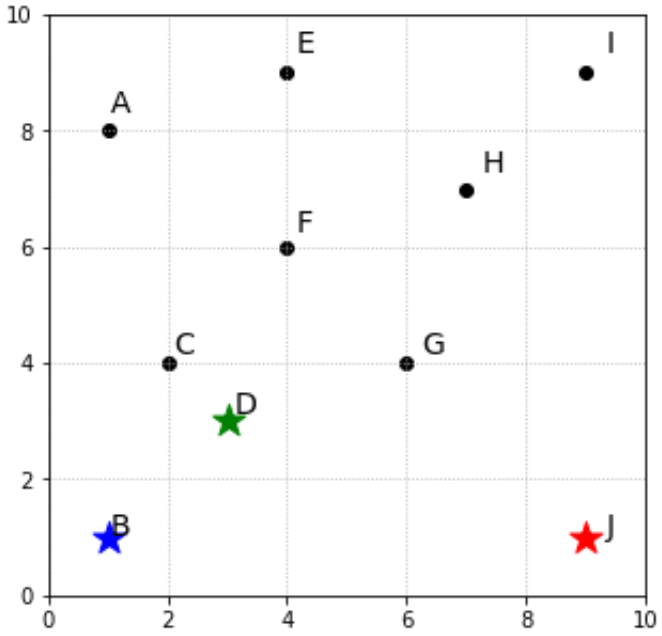
```
data_labels = np.array(['A','B','C','D','E','F','G','H','I','J'])
```

```
# Number of clusters: 3
k = 3
# Number of datapoints: 10
n = 10
```

```
# Initial Seeds / Centroids
centroids = np.array([[1,1], [3,3], [9,1]])
```

```
# Plot points
epoch = 0
print('epoch : '+str(epoch))
figure = plt.figure(figsize=(5,5))
plt.scatter(data[:,0], data[:,1], color='black')
colors_map = ['blue', 'green', 'red']
plt.xlim(0, 10)
plt.ylim(0, 10)
for i, text in enumerate(data_labels):
    plt.annotate(text, (data[i,0]*(1.04), data[i,1]*(1.04)), fontsize = 14)
for i in range(k):
    plt.scatter(centroids[i,0], centroids[i,1], marker='*',
color=colors_map[i], s=250)

plt.grid(which='both', linestyle='dotted')
plt.show()
```

```
epoch : 0
```

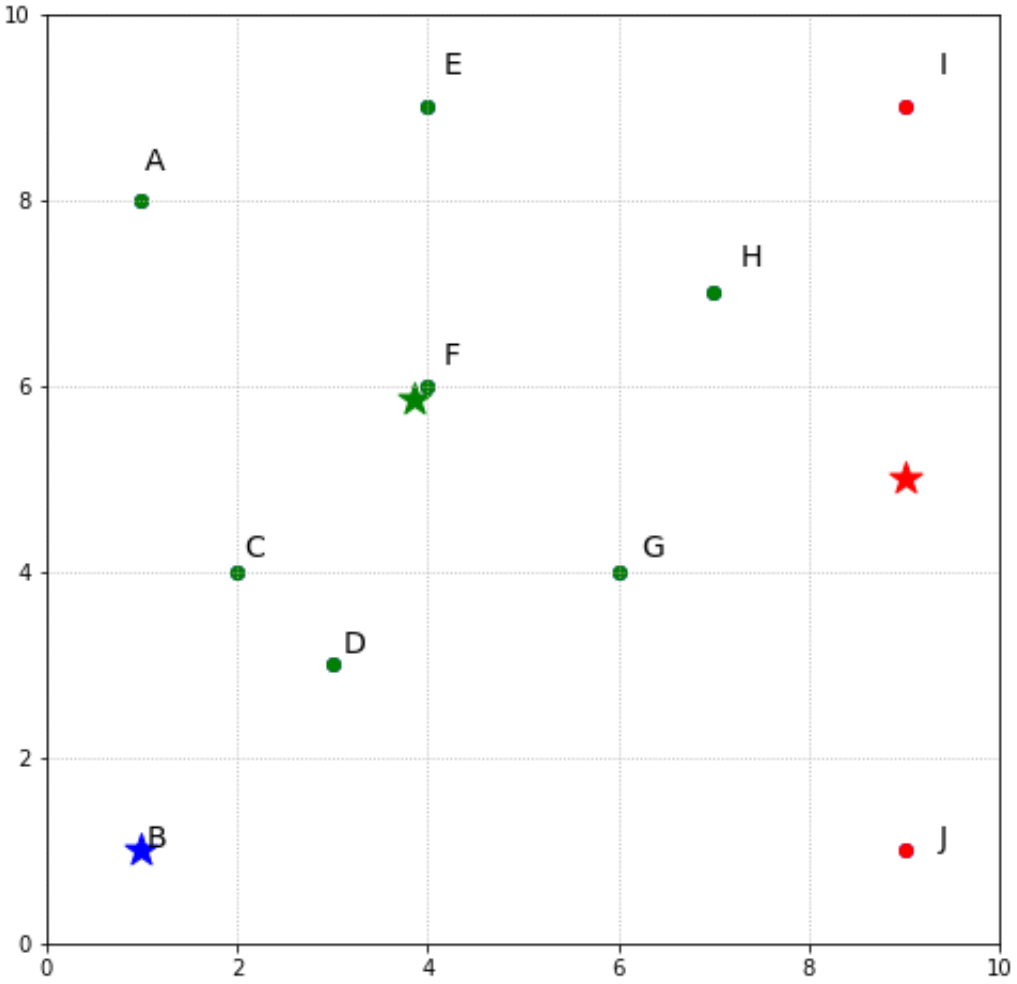


(a) Running 1 round of K-means

```
epoch += 1
print('epoch: '+str(epoch))
distances = np.zeros(shape=(n,k))
clusters = np.zeros(n)

new_centroids = np.zeros(centroids.shape)
old_centroids = deepcopy(centroids)


for i in range(k):
    distances[:,i] = np.linalg.norm(data - centroids[i], axis = 1)
clusters = np.argmin(distances, axis = 1)

old_centroids = deepcopy(new_centroids)

# print('\n Clusters: {}'.format(clusters))
# Calculating new centroids
for i in range(k):
    new_centroids[i] = np.mean([list(x) for x,y in zip(data,clusters) if y ==
i], axis=0)


print('Distances from-')
print('\tCluster_0 Centroid \tCluster_1 Centroid \tCluster_2 Centroid')
for i in range(n):
    for j in range(k):
```

```
        print ('\t{:.4f}\t\t'.format(distances[i][j]), end='')
    print()

print('-----------------------------------------------')
print('Coordinates of the new centroids :-')
for i in range(k):
    print('\tCluster_{} Centroid: '.format(i), end='')
    for j in range(2):
        print ('\t{:.4f}'.format(distances[i][j]), end='')
    print()

print('------------------------------')
print('New Clusters are :-')
for i in range(k):
    print('\tCluster_{} : '.format(i), end='')
    print (' '.join(y for x,y in zip(clusters,data_labels) if x ==i))

scatter_plot(data, new_centroids,clusters)
```

```
epoch: 1
Distances from-
    Cluster_0 Centroid  Cluster_1 Centroid  Cluster_2 Centroid
    7.0000          5.3852          10.6301
    0.0000          2.8284          8.0000
    3.1623          1.4142          7.6158
    2.8284          0.0000          6.3246
    8.5440          6.0828          9.4340
    5.8310          3.1623          7.0711
    5.8310          3.1623          4.2426
    8.4853          5.6569          6.3246
    11.3137         8.4853          8.0000
    8.0000          6.3246          0.0000
-----------------------------------------------
Coordinates of the new centroids :-
    Cluster_0 Centroid:     7.0000  5.3852
    Cluster_1 Centroid:     0.0000  2.8284
    Cluster_2 Centroid:     3.1623  1.4142
------------------------------
New Clusters are :-
    Cluster_0 : B
    Cluster_1 : A C D E F G H
    Cluster_2 : I J
```



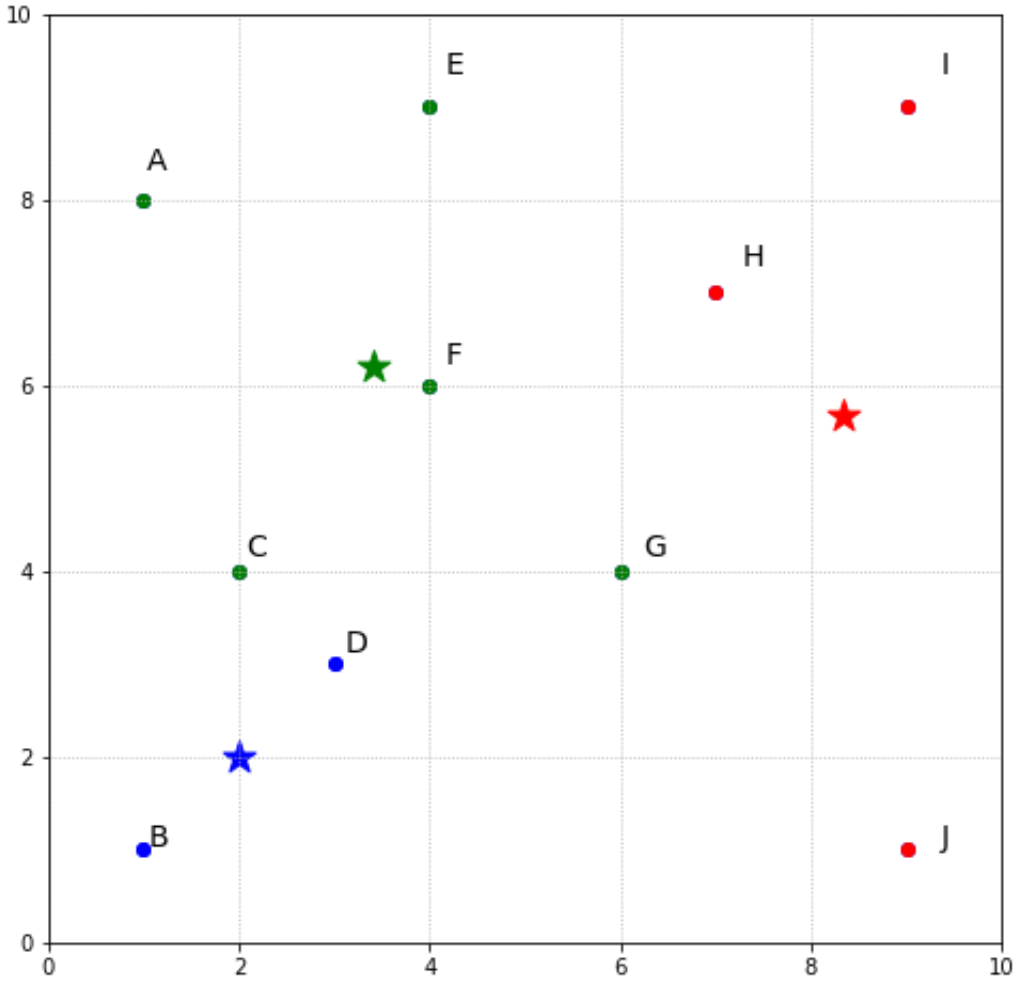
(b) K - means clustering alogrithm rounds

```
epoch = 2
while not np.array_equal(new_centroids, old_centroids) :
    print('------------------------------------------------------------')
    print('------------------------------------------------------------')
    print('epoch : '+str(epoch))
#     distances = np.zeros(shape=(n,k))
#     clusters = np.zeros(k)

    for i in range(k):
        distances[:,i] = np.linalg.norm(data - new_centroids[i], axis = 1)
    clusters = np.argmin(distances, axis = 1)

    old_centroids = deepcopy(new_centroids)

    # Calculating new centroids
    # new_centroids[i] = np.mean(data[clusters == i], axis=0)
    for i in range(k):
```

```
        # print('Cluster points: {}'.format([list(x) for x,y in
zip(data,clusters) if y == i]))
        new_centroids[i] = np.mean([list(x) for x,y in zip(data,clusters) if y
== i], axis=0)

    print('Distances from-')
    print('\tCluster_0 Centroid \tCluster_1 Centroid \tCluster_2 Centroid')
    for i in range(n):
        for j in range(k):
            print ('\t{:.4f}\t\t'.format(distances[i][j]), end='')
        print()

    print('------------------------------')
    print('New Clusters are :-')
    for i in range(k):
        print('\tCluster_{} : '.format(i), end='')
        print (' '.join(y for x,y in zip(clusters,data_labels) if x ==i))

    print('---------------------------------------')
    print('Coordinates of the new centroids :-')
    for i in range(k):
        print('\tCluster_{} Centroid: '.format(i), end='')
        for j in range(2):
            print ('\t{:.4f}'.format(new_centroids[i][j]), end='')
        print()

    scatter_plot(data, new_centroids, clusters)
    epoch += 1
```

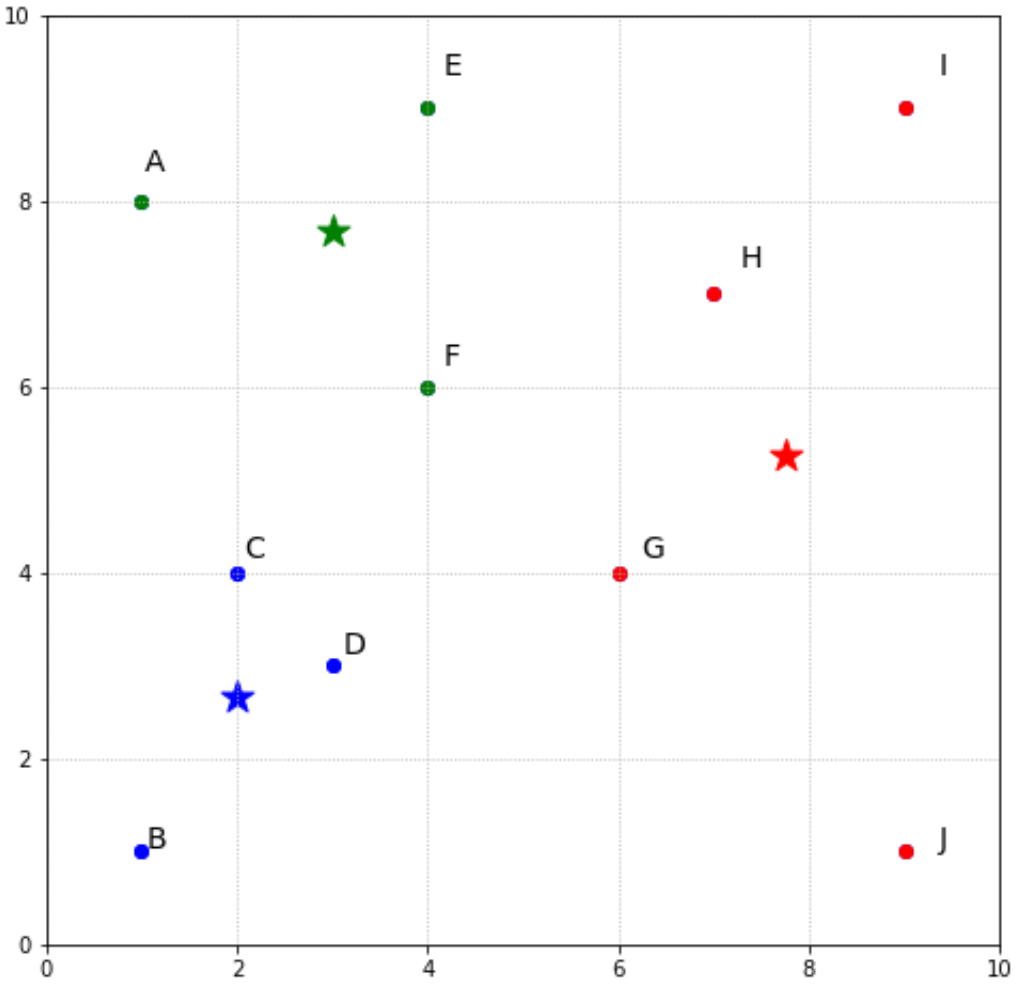
```
------------------------------------------------------------
------------------------------------------------------------
epoch : 2
Distances from-
    Cluster_0 Centroid  Cluster_1 Centroid  Cluster_2 Centroid
    7.0000          3.5714          8.5440
    0.0000          5.6352          8.9443
    3.1623          2.6264          7.0711
    2.8284          2.9829          6.3246
    8.5440          3.1461          6.4031
    5.8310          0.2020          5.0990
    5.8310          2.8356          3.1623
    8.4853          3.3442          2.8284
    11.3137         6.0271          4.0000
    8.0000          7.0740          4.0000
------------------------------
```

```
New Clusters are :-
    Cluster_0 : B D
    Cluster_1 : A C E F G
    Cluster_2 : H I J
---------------------------------------
Coordinates of the new centroids :-
    Cluster_0 Centroid:     2.0000  2.0000
    Cluster_1 Centroid:     3.4000  6.2000
    Cluster_2 Centroid:     8.3333  5.6667
```

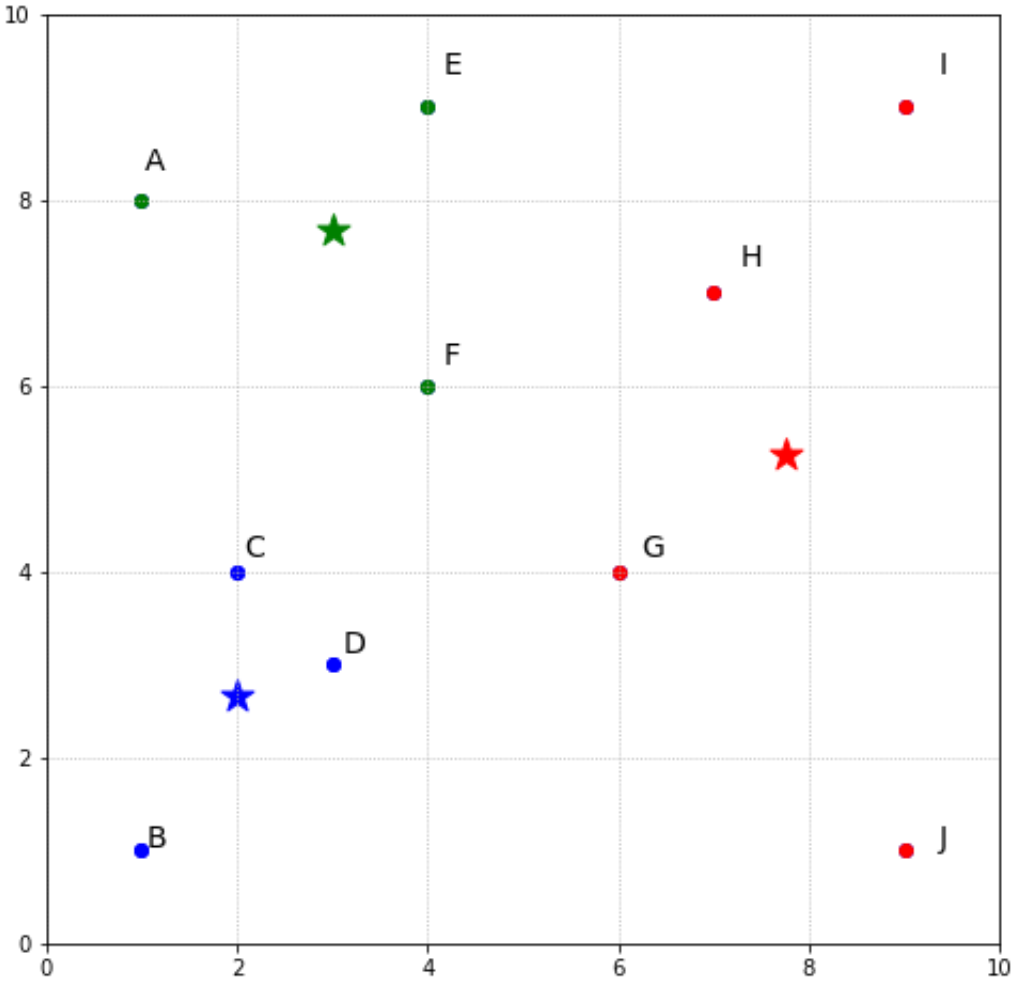



```
------------------------------------------------------------
------------------------------------------------------------
epoch : 3
Distances from-
    Cluster_0 Centroid  Cluster_1 Centroid  Cluster_2 Centroid
    6.0828          3.0000          7.6956
    1.4142          5.7271          8.6923
    2.0000          2.6077          6.5490
```

```
     1.4142          3.2249          5.9628
     7.2801          2.8636          5.4671
     4.4721          0.6325          4.3461
     4.4721          3.4059          2.8674
     7.0711          3.6878          1.8856
     9.8995          6.2610          3.3993
     7.0711          7.6420          4.7140
------------------------------
New Clusters are :-
    Cluster_0 : B C D
    Cluster_1 : A E F
    Cluster_2 : G H I J
--------------------------------------
Coordinates of the new centroids :-
    Cluster_0 Centroid:     2.0000  2.6667
    Cluster_1 Centroid:     3.0000  7.6667
    Cluster_2 Centroid:     7.7500  5.2500
```



```
------------------------------------------------------------
------------------------------------------------------------
epoch : 4
Distances from-
    Cluster_0 Centroid  Cluster_1 Centroid  Cluster_2 Centroid
    5.4263          2.0276          7.2887
    1.9437          6.9602          7.9765
    1.3333          3.8006          5.8843
    1.0541          4.6667          5.2559
    6.6416          1.6667          5.3033
    3.8873          1.9437          3.8243
    4.2164          4.7376          2.1506
    6.6165          4.0552          1.9039
    9.4399          6.1464          3.9528
    7.1957          8.9691          4.4300
------------------------------
New Clusters are :-
    Cluster_0 : B C D
    Cluster_1 : A E F
    Cluster_2 : G H I J
--------------------------------------
Coordinates of the new centroids :-
    Cluster_0 Centroid:     2.0000  2.6667
    Cluster_1 Centroid:     3.0000  7.6667
    Cluster_2 Centroid:     7.7500  5.2500
```



Conclusion:

- Total 3 rounds required for K-means clustering algorithm to converge.
- Here in the figure, cluster's centroid points are indicated with star symbol.
- 3 clusters are denoted with blue, green and red.

For Q2 (c) calculating SSE

```
#print('Distances from-')
#print('\tCluster_0 Centroid \tCluster_1 Centroid \tCluster_2 Centroid')
ss = 0
for i in range(k):
        cluster_points = [list(x) for x,y in zip(data,clusters) if y == i]
        # print('Cluster Points: {}'.format(cluster_points))
        distances = np.linalg.norm(cluster_points - new_centroids[i], axis =
1)
        ss += sum([x*x for x in distances ])
print('K-Means SSE: {}'.format(ss))
```

```
K-Means SSE: 60.83333333333333
```