CS 584-04: Machine Learning

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Spring 2020 Assignment 2

Question 1 (35 points)

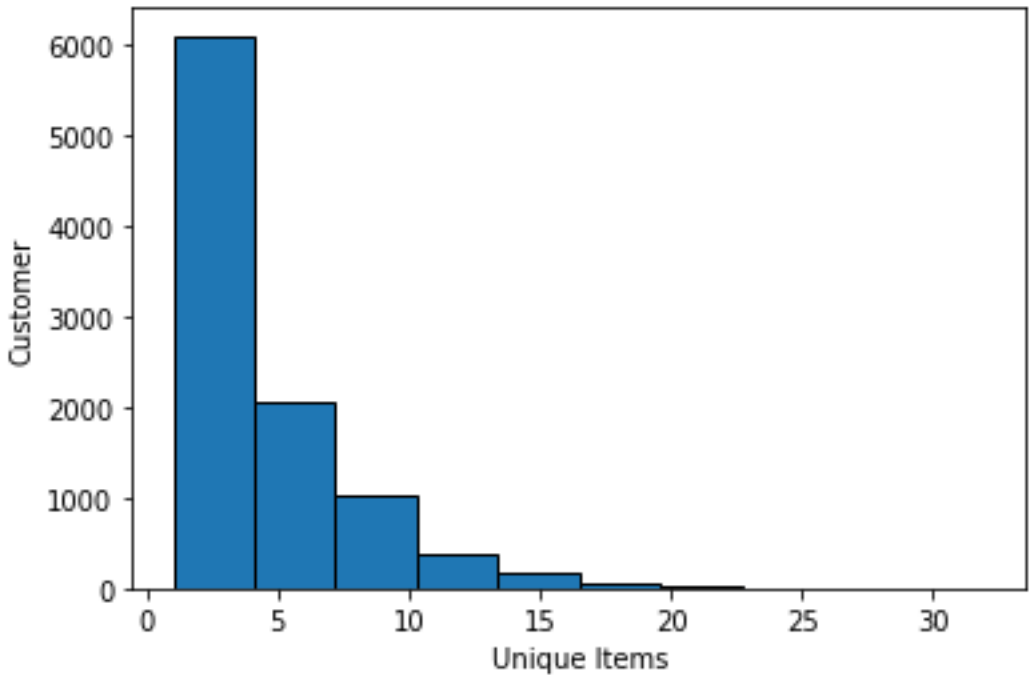
The file Groceries.csv contains market basket data. The variables are:

1. Customer: Customer Identifier
2. Item: Name of Product Purchased

After you have imported the CSV file, please discover association rules using this dataset. For your information, the observations have been sorted in ascending order by Customer and then by Item. Also, duplicated items for each customer have been removed.

a) (5 points) Create a data frame that contains the number of unique items in each customer's market basket. Draw a histogram of the number of unique items. What are the 25th, 50th, and the 75th percentiles of the histogram?

Answer:

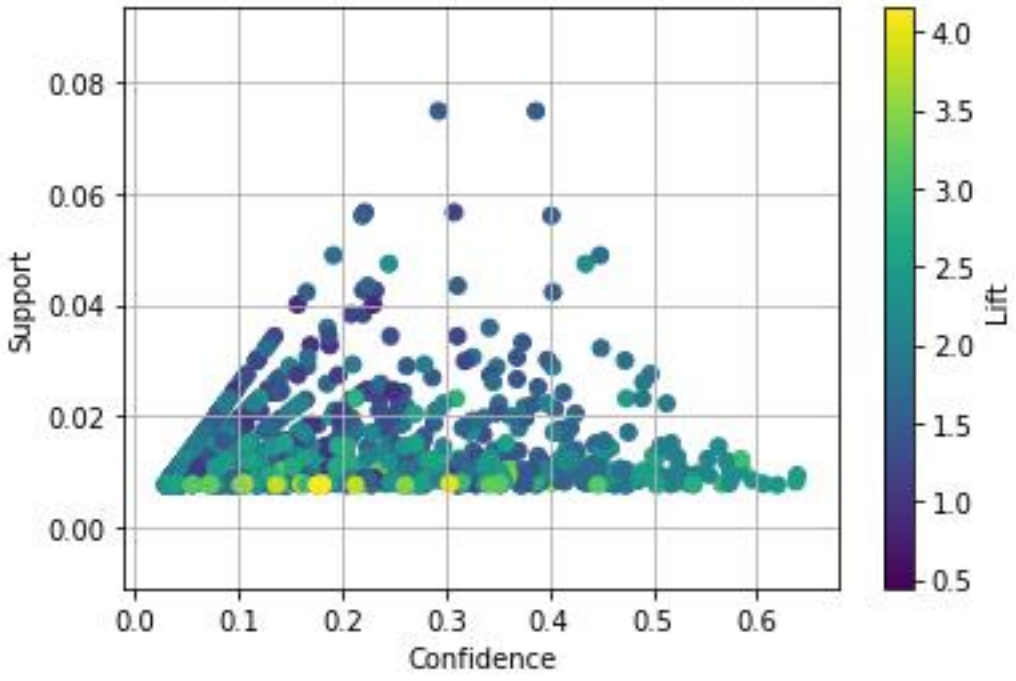


25th Percentaile:2.0
50th Percentiles:3.0
75th Percentiles:6.0

b) (10 points) We are only interested in the *k*-itemsets that can be found in the market baskets of at least seventy five (75) customers. How many itemsets can we find? Also, what is the largest *k* value among our itemsets?
Answer : Number of itemsets found:524
The largest k value among our itemsets:4

c) (10 points) Find out the association rules whose Confidence metrics are greater than or equal to 1%. How many association rules can we find? Please be reminded that a rule must have a non-empty antecedent and a non-empty consequent. Please **do not** display those rules in your answer.
Answer : Number of Association Rules: 1228

d) (5 points) Plot the Support metrics on the vertical axis against the Confidence metrics on the horizontal axis for the rules you have found in (c). Please use the Lift metrics to indicate the size of the marker.
Answer :



e) (5 points) List the rules whose Confidence metrics are greater than or equal to 60%. Please include their Support and Lift metrics.
Answer :

```
antecedents    (root vegetables, butter)
consequents                (whole milk)
support                     0.00823589
lift                           2.49611
Name: 728, dtype: object


antecedents    (yogurt, butter)
consequents         (whole milk)
support               0.00935435
lift                     2.50039
Name: 734, dtype: object
```

```
antecedents    (other vegetables, yogurt, root vegetables)
consequents                                     (whole milk)
support                                       0.00782918
lift                                             2.37284
Name: 1203, dtype: object


antecedents    (other vegetables, tropical fruit, yogurt)
consequents                                    (whole milk)
support                                      0.00762583
lift                                            2.42582
Name: 1217, dtype: object
```

Question 2 (30 points)

The K-means algorithm works only with interval features. One way to apply the k-means algorithm to categorical features is to transform them into a new interval feature space. However, this approach can be very inefficient, and it does not produce good results.

For clustering categorical features, we should consider the K-modes clustering algorithm which extends the K-means algorithm by using different dissimilarity measures and a different method for computing cluster centers. See this article for more details. Huang, Z. (1997). "A Fast Clustering Algorithm to Cluster Very Large Categorical Data Sets in Data Mining." In Proceedings of the *SIGMOD Workshop on Research Issues on Data Mining and Knowledge Discovery*, 1–8. New York: ACM Press.

Please implement the K-modes clustering method in Python and then apply the method to the cars.csv. Your input fields are these four categorical features: Type, Origin, DriveTrain, and Cylinders. **Please do not remove the missing or blank values in these four features**. Instead, consider these values as a separate category.

The cluster centroids are the modes of the input fields. In the case of tied modes, choose the lexically or numerically lowest one.

Suppose a categorical feature has observed values $v_1, \ldots, v_p$. Their global frequencies (i.e., number of observations) are $f_1, \ldots, f_p$. Please be noted that these global frequencies do not change with the cluster assignment. The distance metric between two values is $d(v_i, v_j) = 0$ if $v_i = v_j$. Otherwise, $d(v_i, v_j) = \frac{1}{f_i} + \frac{1}{f_j}$. The distance between any two observations is the sum of the distance metric of the four categorical features.

a) (5 points) What are the frequencies of the categorical feature Type?

Answer :

Frequencies of the categorical feature

[60 262 49 30 24 3]

'Type':

	Type	Freq_Type
0	SUV	60
1	Sedan	262
2	Sedan	262
3	Sedan	262
4	Sedan	262
5	Sedan	262
6	Sports	49
7	Sedan	262
8	Sedan	262
9	Sedan	262
10	Sedan	262
11	Sedan	262
12	Sedan	262
13	Sedan	262
14	Sedan	262

15	Sedan	262
16	Sedan	262
17	Sedan	262
18	Sedan	262
19	Sedan	262
20	Sports	49
21	Sports	49
22	Sports	49
23	Sports	49
24	Wagon	30
25	Wagon	30
26	SUV	60
27	SUV	60
28	Sedan	262
29	Sedan	262
..	...	...
398	Truck	24
399	Truck	24
400	Wagon	30
401	SUV	60
402	Sedan	262
403	Sedan	262
404	Sedan	262
405	Sedan	262
406	Sedan	262
407	Sedan	262
408	Sedan	262
409	Sedan	262
410	Sedan	262
411	Sedan	262
412	Sedan	262
413	Wagon	30
414	Wagon	30
415	Wagon	30
416	SUV	60
417	Sedan	262
418	Sedan	262
419	Sedan	262
420	Sedan	262
421	Sedan	262
422	Sedan	262
423	Sedan	262
424	Sedan	262
425	Sedan	262

426 Wagon 30
427 Wagon 30

b) (5 points) What are the frequencies of the categorical feature DriveTrain?

Answer :

Frequencies of the categorical feature : [92 226 110]

'Type':	DriveTrain	Freq_DriveTrain
0	AWD	92
1	FWD	226
2	FWD	226
3	FWD	226
4	FWD	226
5	FWD	226
6	RWD	110
7	FWD	226
8	FWD	226
9	FWD	226
10	AWD	92
11	AWD	92
12	FWD	226
13	AWD	92
14	FWD	226
15	AWD	92
16	AWD	92
17	AWD	92
18	AWD	92
19	AWD	92
20	FWD	226
21	FWD	226
22	AWD	92
23	AWD	92
24	AWD	92
25	AWD	92
26	AWD	92
27	AWD	92
28	RWD	110
29	RWD	110
..	...	...
398	RWD	110
399	AWD	92
400	FWD	226
401	AWD	92
402	FWD	226
403	FWD	226

404	**FWD**	**226**
405	**FWD**	**226**
406	**FWD**	**226**
407	**FWD**	**226**
408	**FWD**	**226**
409	**FWD**	**226**
410	**FWD**	**226**
411	**FWD**	**226**
412	**FWD**	**226**
413	**FWD**	**226**
414	**FWD**	**226**
415	**FWD**	**226**
416	**AWD**	**92**
417	**FWD**	**226**
418	**AWD**	**92**
419	**FWD**	**226**
420	**AWD**	**92**
421	**FWD**	**226**
422	**AWD**	**92**
423	**FWD**	**226**
424	**FWD**	**226**
425	**FWD**	**226**
426	**FWD**	**226**
427	**AWD**	**92**

c) (5 points) What is the distance metric between 'Asia' and 'Europe' for Origin?
Answer : Distance between Asia and Europe is : 0.014459195224863643

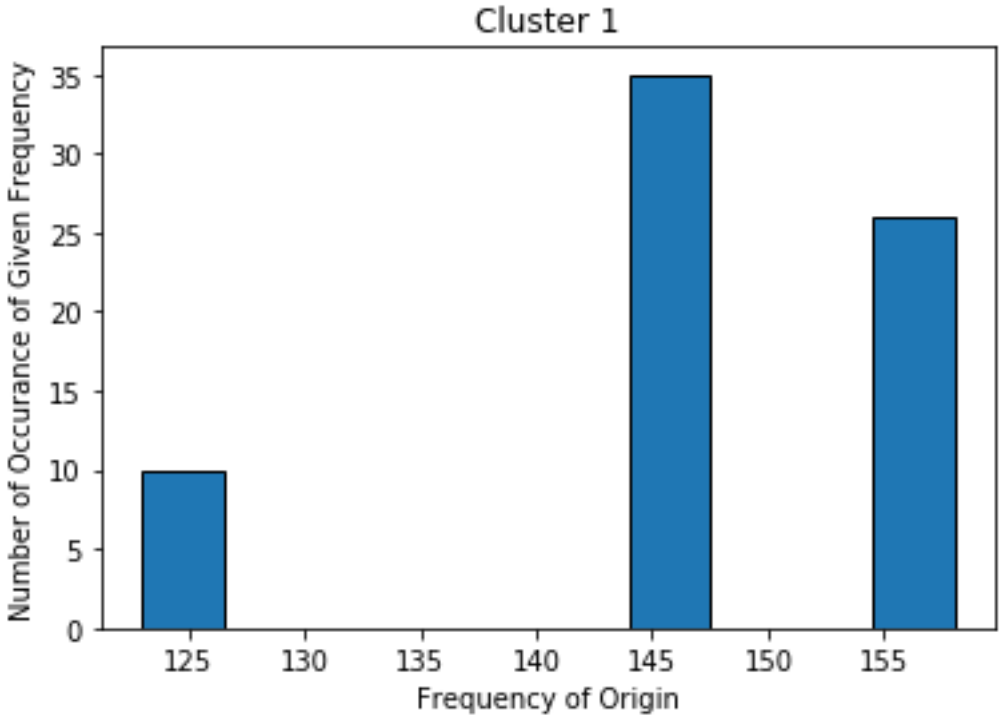
d) (5 points) What is the distance metric between Cylinders = 5 and Cylinders = Missing?
Answer : Distance between Cylinder5 and Cylinder0 is : 0.6428571428571428

e) (5 points) Apply the K-modes method with **three clusters**. How many observations in each of these three clusters? What are the centroids of these three clusters?
Answer :
Number of Observations in Cluster1: 71
Number of Observations in Cluster2: 216
Number of Observations in Cluster3: 141
Centroid of CLuster 1: [60.0, 147.0, 92.0, 190.0] ['SUV', 'USA', 'AWD', 6.0]
Centroid of CLuster 2: [262.0, 158.0, 226.0, 136.0] ['Sedan', 'Europe', 'FWD', 6.0]
Centroid of CLuster 3: [262.0, 123.0, 110.0, 190.0] ['Sedan', 'Asia', 'FWD', 4.0]

f) (5 points) Display the frequency distribution table of the Origin feature in each cluster.

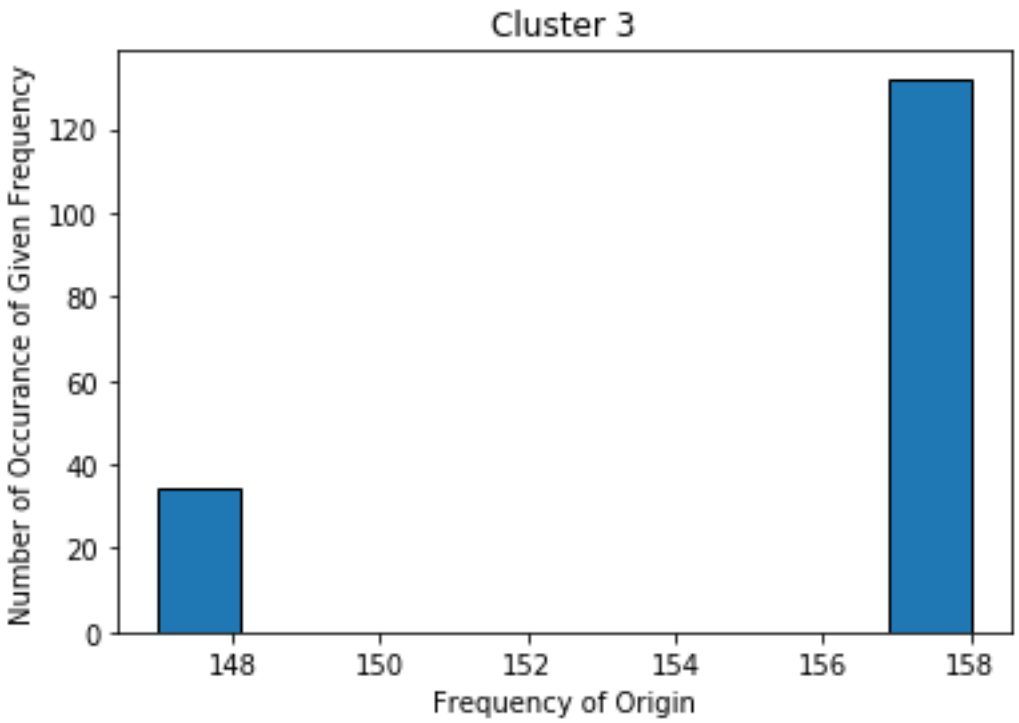
Answer:

Frequency Distribution of Cluster 1: Asia :26, Europe:10, USA:35



Frequency Distribution of Cluster 2: Asia :0, Europe:113, USA:78

Frequency Distribution of Cluster 3: Asia :132, Europe:0, USA:34

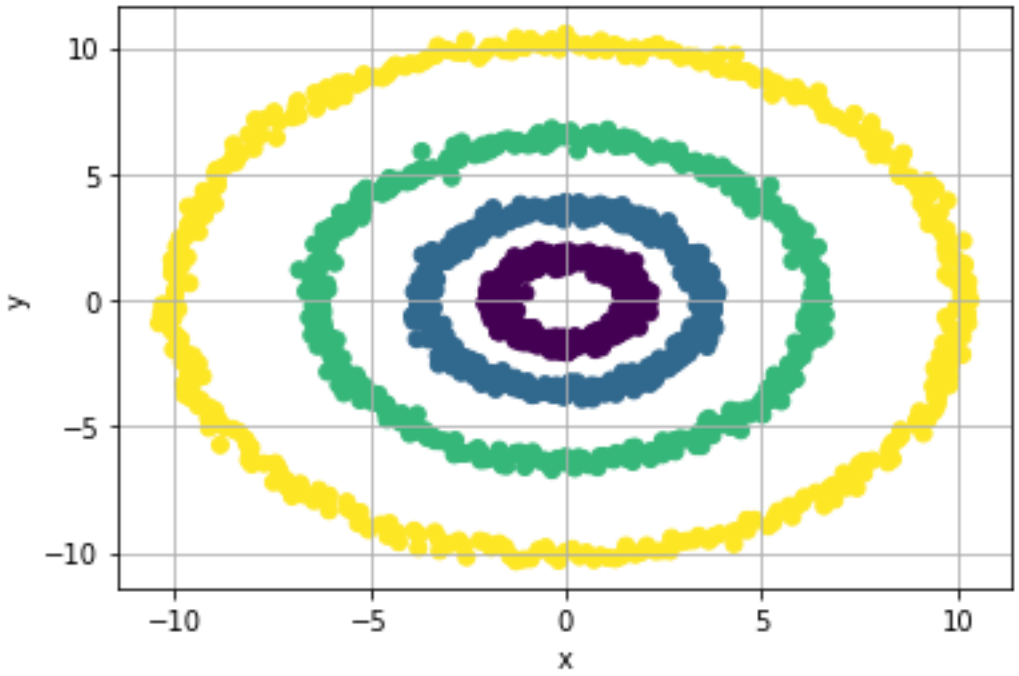

Cluster 3
Number of Occurance of Given Frequency
0
20
40
60
80
100
120
148
150
152
154
156
158
Frequency of Origin

Question 3 (35 points)

Apply the Spectral Clustering method to the FourCircle.csv. Your input fields are x and y. Wherever needed, specify random_state = 60616 in calling the KMeans function.

a) (5 points) Plot y on the vertical axis versus x on the horizontal axis. How many clusters are there based on your visual inspection?

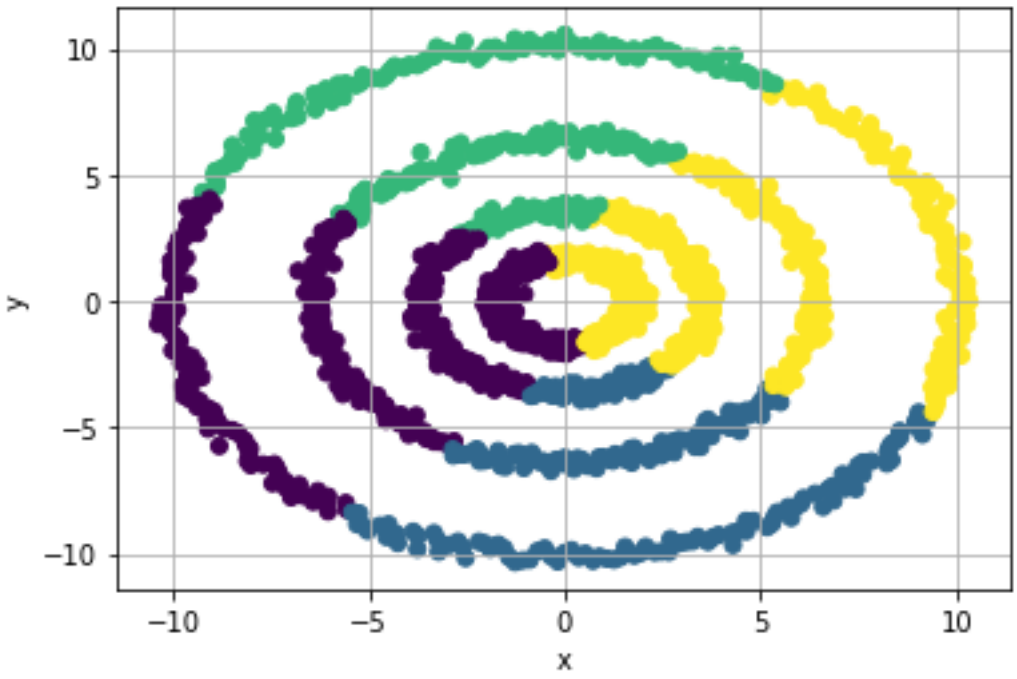
Answer : Based on my observation , number of clusters are 4.



b) (5 points) Apply the K-mean algorithm directly using your number of clusters that you think in (a). Regenerate the scatterplot using the K-mean cluster identifiers to control the color scheme. Please comment on this K-mean result.

Answer :

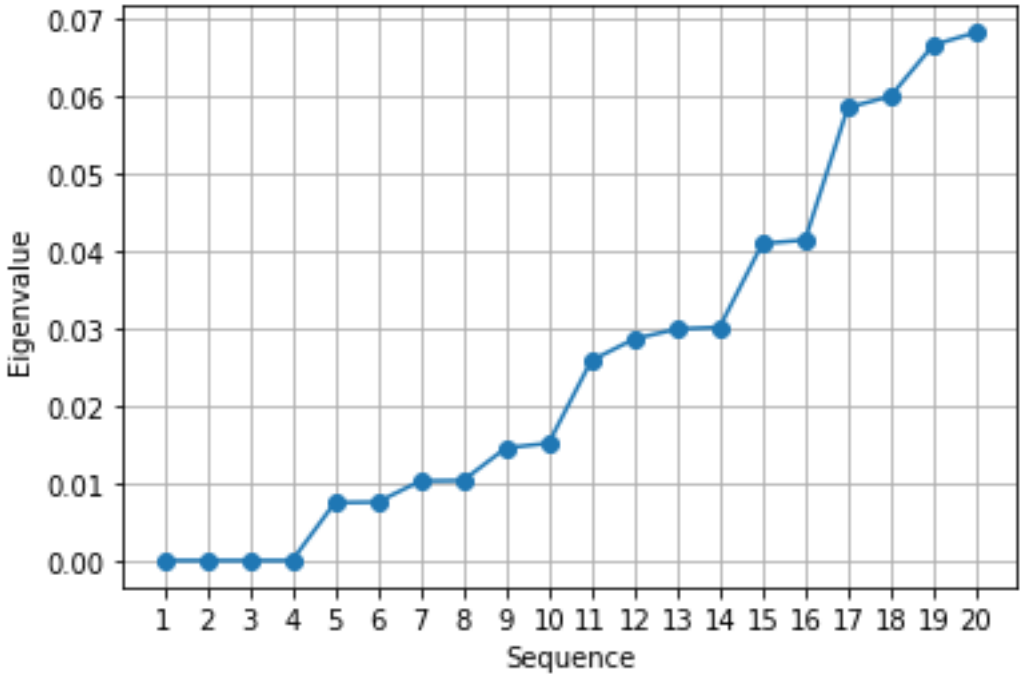
The below graph shows that without transforming the data we get wrong results from K mean clustering algorithm. The points which belong to different clusters has been assigned to same clusters as shown below with different colors. Hence we can not use K mean clustering algorithm directly to categorical data without transforming it.



c) (10 points) Apply the nearest neighbor algorithm using the Euclidean distance. We will consider the number of neighbors from 1 to 15. What is the smallest number of neighbors that we should use to discover the clusters correctly? Remember that we may need to try a couple of values first and use the eigenvalue plot to validate our choice.

Answer :

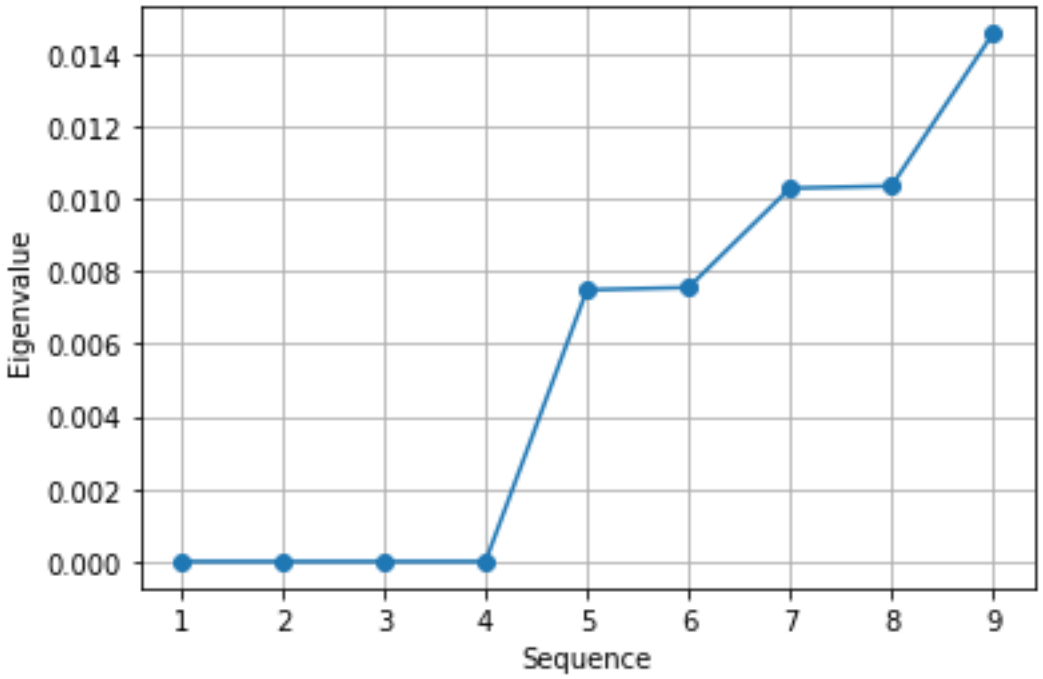
The smallest number of neighbors that we should use to discover the clusters correctly: 10



d) (5 points) Using your choice of the number of neighbors in (c), calculate the Adjacency matrix, the Degree matrix, and finally the Laplacian matrix. How many eigenvalues do you determine are practically zero? Please display values of the "zero" eigenvalues in scientific notation.

Answer :

Values of the "zero" eigenvalues in scientific notation: [-7.33258899e-16 2.84331459e-16 1.28367511e-15 1.40853702e-15]



Adajacency Matrix

```
[[1.      0.      0.      ... 0.      0.      0.     ]
 [0.      1.      0.      ... 0.86087673 0.      0.     ]
 [0.      0.      1.      ... 0.      0.96602229 0.     ]
 ...
 [0.      0.86087673 0.      ... 1.      0.      0.     ]
 [0.      0.      0.96602229 ... 0.      1.      0.     ]
 [0.      0.      0.      ... 0.      0.      1.     ]]
```

Degree Matrix

```
[[8.37508495 0.       0.       ... 0.       0.       0.      ]
 [0.       9.08018606 0.       ... 0.       0.       0.      ]
 [0.       0.       8.67243781 ... 0.       0.       0.      ]
 ...
 [0.       0.       0.       ... 9.22996601 0.       0.      ]
 [0.       0.       0.       ... 0.       7.80266431 0.      ]
 [0.       0.       0.       ... 0.       0.       7.17690085]]
```

Laplacian matrix

```
[[ 7.37508495  0.         0.        ...  0.         0.
   0.        ]
 [ 0.         8.08018606  0.        ... -0.86087673  0.
   0.        ]
 [ 0.         0.         7.67243781 ...  0.        -0.96602229
   0.        ]
 ...
 [ 0.        -0.86087673  0.        ...  8.22996601  0.
   0.        ]
 [ 0.         0.        -0.96602229 ...  0.         6.80266431
   0.        ]
 [ 0.         0.         0.        ...  0.         0.
   6.17690085]]
```

e) (10 points) Apply the K-mean algorithm on the eigenvectors that correspond to your "practically" zero eigenvalues. The number of clusters is the number of your "practically" zero eigenvalues. Regenerate the scatterplot using the K-mean cluster identifier to control the color scheme.

Answer :