Introduction to Python Programming

DSCI-D 590 (Topics in Data Science)

Final Project

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Project Statement: This project involves using the k-means clustering algorithm to analyze the Wisconsin Breast Cancer data set to classify patients as either class 2 (benign) or class 4 (malignant).

Phase 1: This phase involves importing the dataset into the program as a data frame. This phase also handles values in the dataset listed as ‘?’ and replacing the values with the mean value of the entire column. The mean, median, standard deviation, and variance are calculated for each of the attributes. The value frequency for each attribute was modeled using histograms. The final output of the program is a table listing the summary statistics for each of the attributes. A total of nine histograms were generated to describe the value frequency of each attribute.

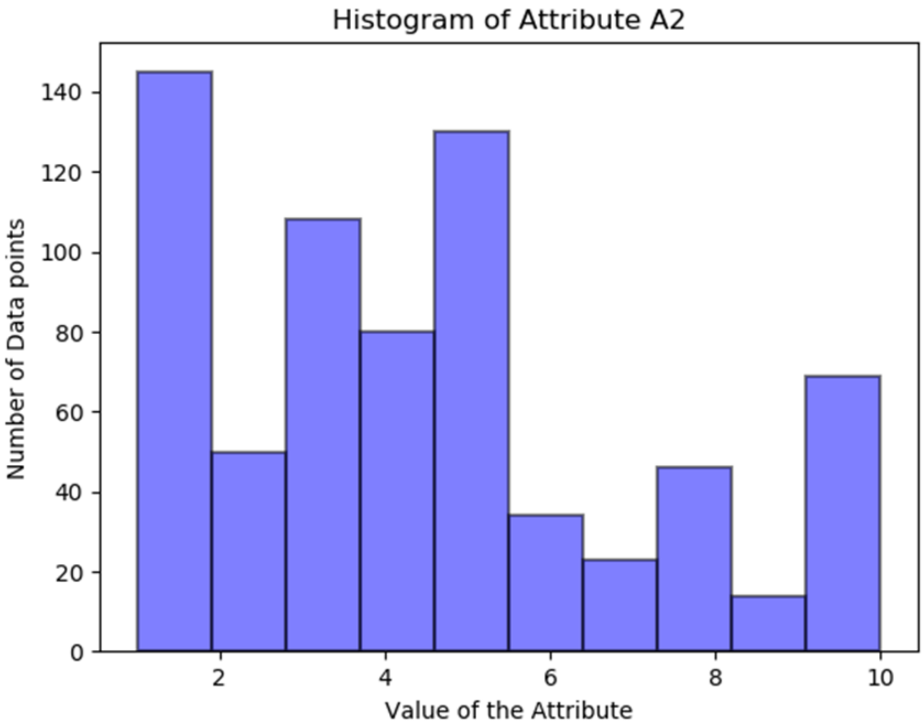
Phase 2: This phase includes three processes for implementing the k-means algorithm. The first step initializes the centroids randomly. The next calculates the distance from the centroids for each of the 699 data points and assigns each data point to either the ‘2’ or ‘4’ cluster in the newly generated ‘Predicted_Class’ column depending on the shortest distance. Once the data points have been assigned to either cluster, the means for each cluster are calculated. The centroids are then updated depending on the cluster means. This process is iterated until the centroids not longer change or there were 50 iterations performed. The final output of phase 2 is comprised of the randomly selected initial centroids, the final centroids after recompilation, and final cluster alignment.

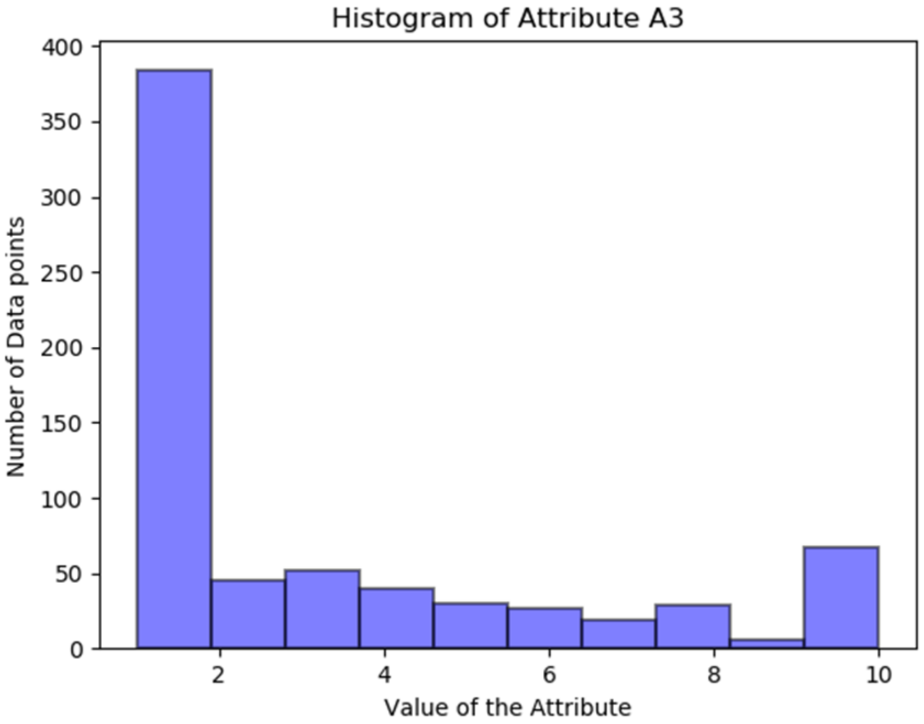
Phase 3: This phase analyzes the quality of the k-means clustering algorithm as performed in Phase 2. The program initially calculates the total error by analyzing the discrepancies between the ‘Class’ and ‘Predicted_Class’ as computed in Phase 2. If the error is greater than 50% the program will then swap the values in the ‘Predicted_Class’ column. The program then summarizes the number of data points, provides an output for the ‘Predicted_Class’ error data points, and calculates the error rate for both class 2 and class 4.

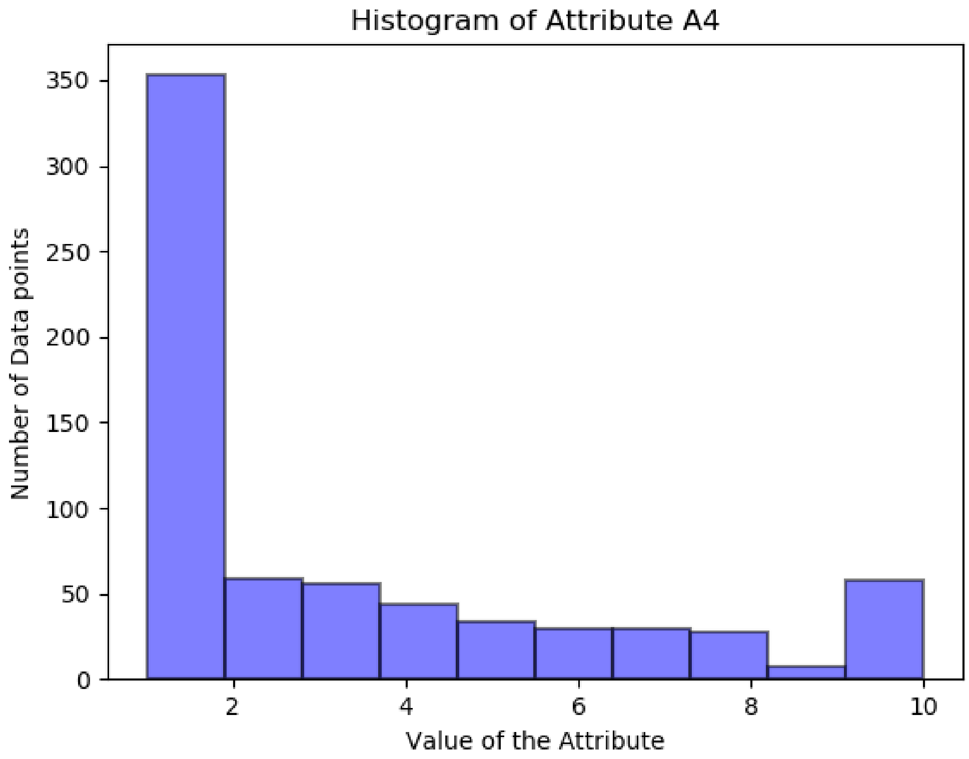
Phase 1 Results:

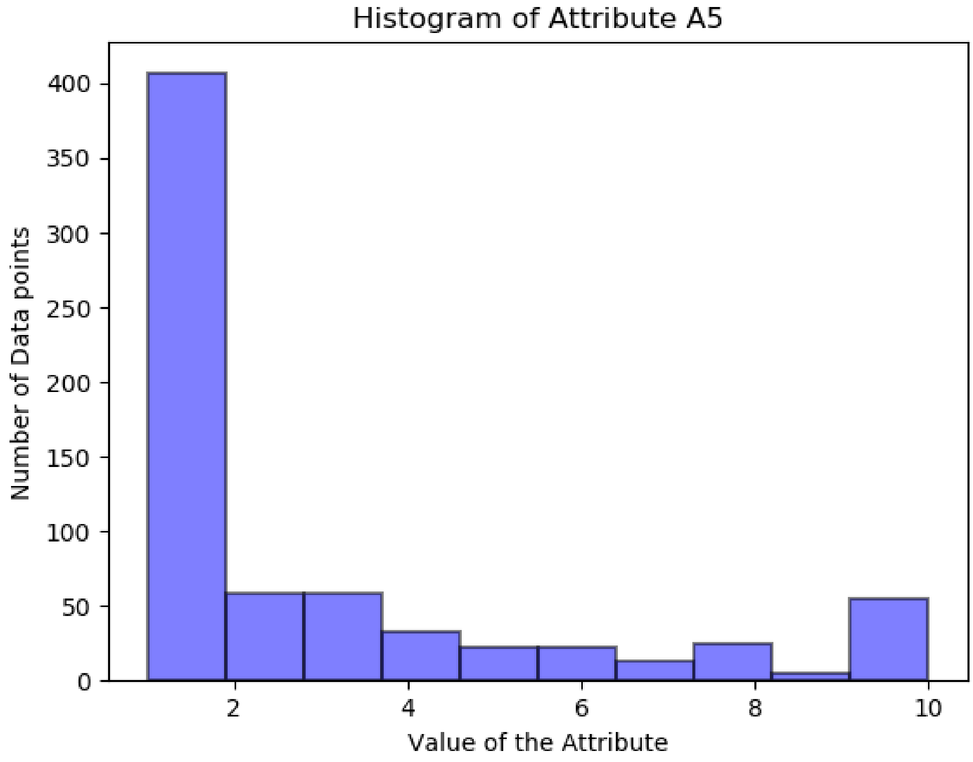
```
Attribute A2 -----------
Mean:                4.4
Median:              4.0
Variance:            7.9
Standard Deviation: 2.8

Attribute A3 -----------
Mean:                3.1
Median:              1.0
Variance:            9.3
Standard Deviation: 3.0

Attribute A4 -----------
```

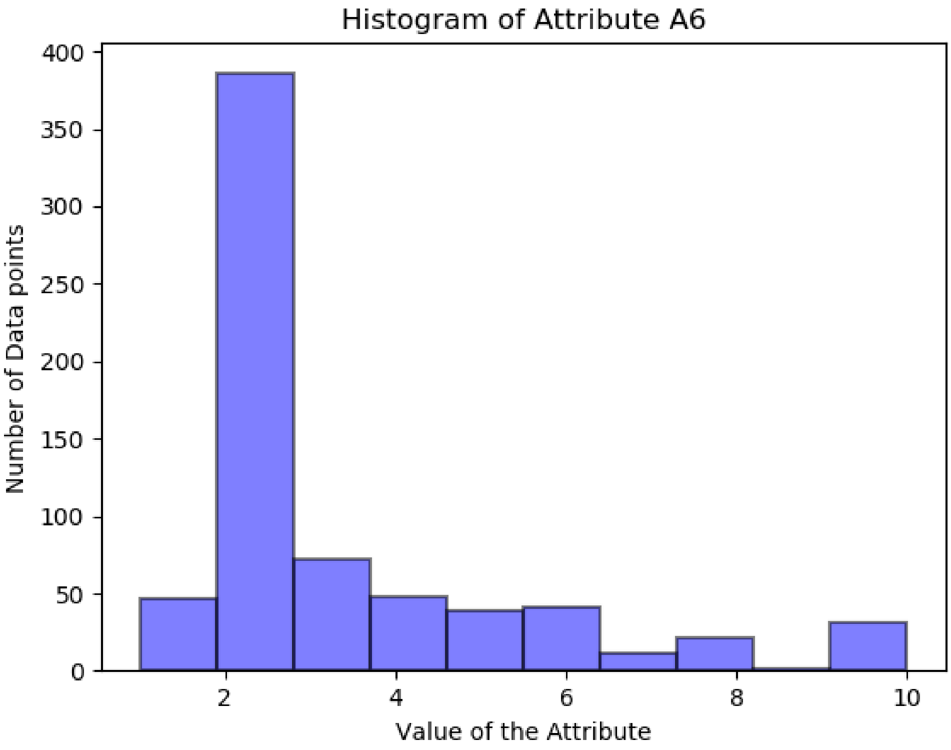
```
Mean:               3.2
Median:             1.0
Variance:           8.8
Standard Deviation: 3.0

Attribute A5 -----------
Mean:               2.8
Median:             1.0
Variance:           8.2
Standard Deviation: 2.9

Attribute A6 -----------
Mean:               3.2
Median:             2.0
Variance:           4.9
Standard Deviation: 2.2

Attribute A7 -----------
Mean:               3.5
Median:             1.0
Variance:          13.0
Standard Deviation: 3.6

Attribute A8 -----------
Mean:               3.4
Median:             3.0
Variance:           5.9
Standard Deviation: 2.4

Attribute A9 -----------
Mean:               2.9
Median:             1.0
Variance:           9.3
Standard Deviation: 3.0

Attribute A10 -----------
Mean:               1.6
Median:             1.0
Variance:           2.9
Standard Deviation: 1.7
```

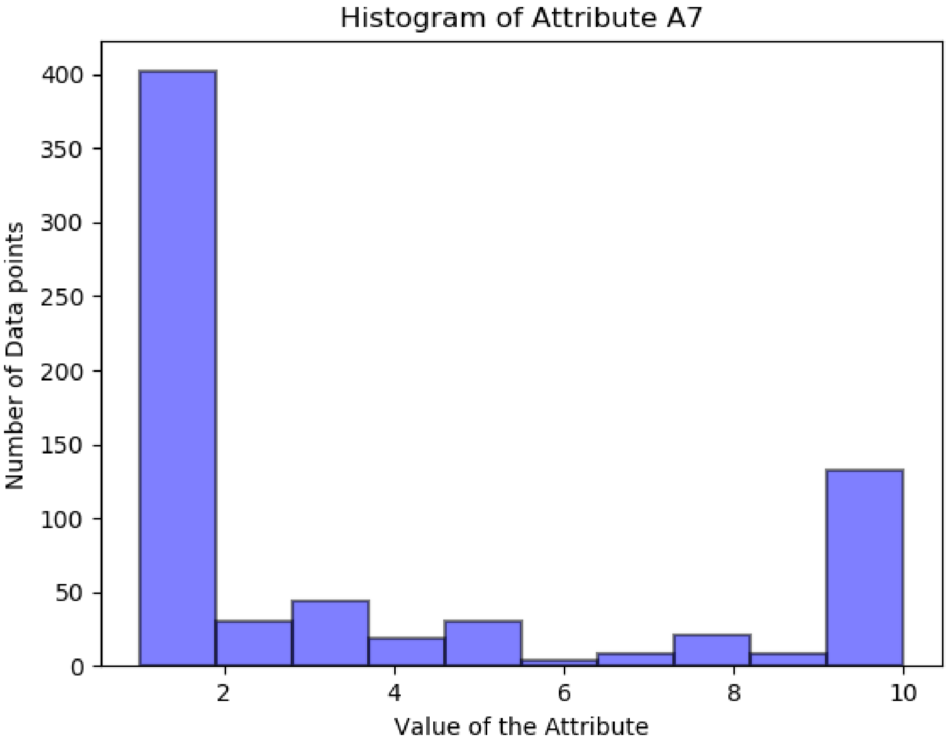

Histogram of Attribute A2

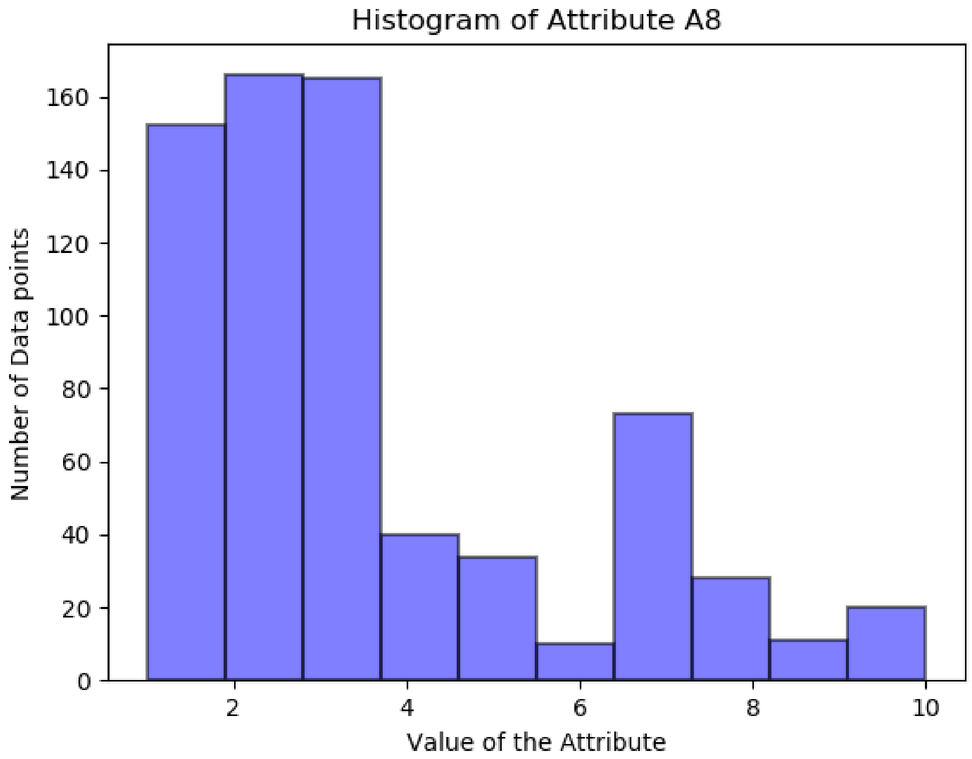

Histogram of Attribute A3

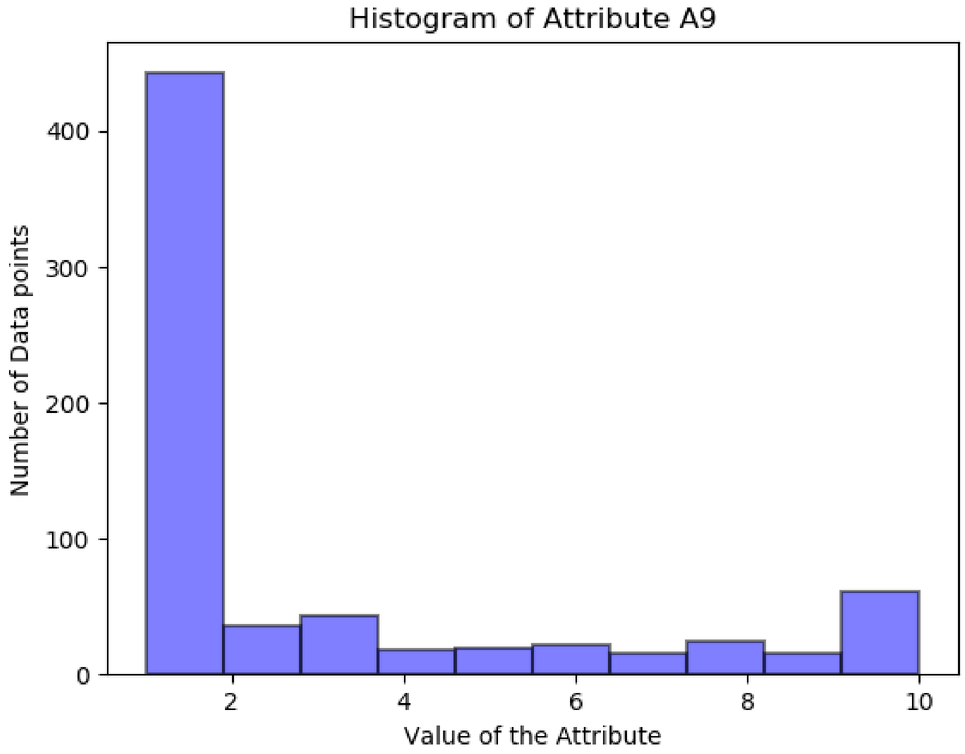

Histogram of Attribute A4
Number of Data points
Value of the Attribute
0
50
100
150
200
250
300
350
2
4
6
8
10


Histogram of Attribute A5
Number of Data points
Value of the Attribute
0
50
100
150
200
250
300
350
400
2
4
6
8
10


Histogram of Attribute A6
Number of Data points
0
50
100
150
200
250
300
350
400
2
4
6
8
10
Value of the Attribute


Histogram of Attribute A7
Number of Data points
0
50
100
150
200
250
300
350
400
2
4
6
8
10
Value of the Attribute


Histogram of Attribute A8
Number of Data points
0
20
40
60
80
100
120
140
160
2
4
6
8
10
Value of the Attribute


Histogram of Attribute A9
Number of Data points
0
100
200
300
400
2
4
6
8
10
Value of the Attribute

Phase 2 Results:

```
Randomly selected row 362 for centroid mu_2.
A2     3.0
A3     2.0
A4     2.0
A5     1.0
A6     4.0
A7     3.0
A8     2.0
A9     1.0
A10    1.0
Name: 362, dtype: float64


Randomly selected row 402 for centroid mu_4.
A2     5.0
A3     3.0
A4     3.0
A5     1.0
A6     2.0
A7     1.0
A8     2.0
A9     1.0
A10    1.0
Name: 402, dtype: float64


Program ended after 8 iterations.

Final centroid for mu_2:
A2     3.047210
A3     1.302575
A4     1.446352
A5     1.343348
A6     2.087983
A7     1.378755
A8     2.105150
A9     1.261803
A10    1.109442
Name: 0, dtype: float64


Final centroid for mu_4:
A2     7.158798
A3     6.798283
A4     6.729614
A5     5.733906
A6     5.472103
A7     7.873391
A8     6.103004
A9     6.077253
A10    2.549356
Name: 1, dtype: float64
```

```
Final cluster assignment:

        Scn  Class  Predicted_Class
0   1000025      2                2
1   1002945      2                4
2   1015425      2                2
3   1016277      2                4
4   1017023      2                2
5   1017122      4                4
6   1018099      2                2
7   1018561      2                2
8   1033078      2                2
9   1033078      2                2
10  1035283      2                2
11  1036172      2                2
12  1041801      4                2
13  1043999      2                2
14  1044572      4                4
15  1047630      4                2
16  1048672      2                2
17  1049815      2                2
18  1050670      4                4
19  1050718      2                2
20  1054590      4                4
```

Phase 3 Results:

```
Output when Clusters are swapped:

Total errors 95.9 %
Clusters are swapped
Swapping Predicted_Class


Number of Data points in Predicted Class 2: 465
Number of Data points in Predicted Class 4: 234

Error data points, Predicted_Class 2:

         Scn  Class  Predicted_Class
12   1041801      4                2
15   1047630      4                2
23   1057013      4                2
50   1108370      4                2
51   1108449      4                2
57   1113038      4                2
59   1113906      4                2
63   1116132      4                2
65   1116998      4                2
```

```
101  1167439      4                2
103  1168359      4                2
105  1169049      4                2
222  1226012      4                2
273   428903      4                2
348   832226      4                2
356   859164      4                2
455  1246562      4                2
489  1084139      4                2


Error data points, Predicted_Class 4:

         Scn  Class  Predicted_Class
1    1002945      2                4
3    1016277      2                4
40   1096800      2                4
196  1213375      2                4
252  1017023      2                4
259   242970      2                4
296   616240      2                4
315   704168      2                4
319   721482      2                4
352   846832      2                4
434  1293439      2                4


Number of all data points: 699

Number of error data points: 29

Error rate for class 2: 3.9 %
Error rate for class 4: 4.7 %
Total error rate: 4.1 %


Output when Clusters are not swapped:

Total errors 4.3 %
Number of Data points in Predicted Class 2: 466
Number of Data points in Predicted Class 4: 233

Error data points, Predicted_Class 2:

         Scn  Class  Predicted_Class
12   1041801      4                2
15   1047630      4                2
23   1057013      4                2
25   1065726      4                2
50   1108370      4                2
51   1108449      4                2
57   1113038      4                2
59   1113906      4                2
63   1116132      4                2
```

```
65   1116998      4               2
101  1167439      4               2
103  1168359      4               2
105  1169049      4               2
222  1226012      4               2
273   428903      4               2
348   832226      4               2
356   859164      4               2
455  1246562      4               2
489  1084139      4               2


Error data points, Predicted_Class 4:

         Scn  Class  Predicted_Class
1    1002945      2                4
3    1016277      2                4
40   1096800      2                4
196  1213375      2                4
252  1017023      2                4
259   242970      2                4
296   616240      2                4
315   704168      2                4
319   721482      2                4
352   846832      2                4
434  1293439      2                4


Number of all data points: 699

Number of error data points: 30

Error rate for class 2: 4.1 %
Error rate for class 4: 4.7 %
Total error rate: 4.3 %
```

Conclusion: The initial phase provides summary statistics and histograms for each attribute in the dataset. The mean range for the attributes was between 1.6 – 4.4, the median range was between 1.0 - 4.0, the variance range was 4.9 – 13.0 and the standard deviation range was from 1.7 – 3.6. During Phase 2, the final centroids for class 2 and class 4 were calculated after eight iterations and produced a final cluster alignment with a predicted class attribute. The error rate of 'Class' compared to 'Predicted_Class' was calculated during phase 3. Overall, the k-means algorithm produces an error rate of approximately 4.1% - 4.3% when comparing the correct 'Class' interpretation versus the 'Predicted_Class' interpretation. The calculated error rate describes how well the final 'Predicted_Class' centroids represent the correct 'Class' clusters.