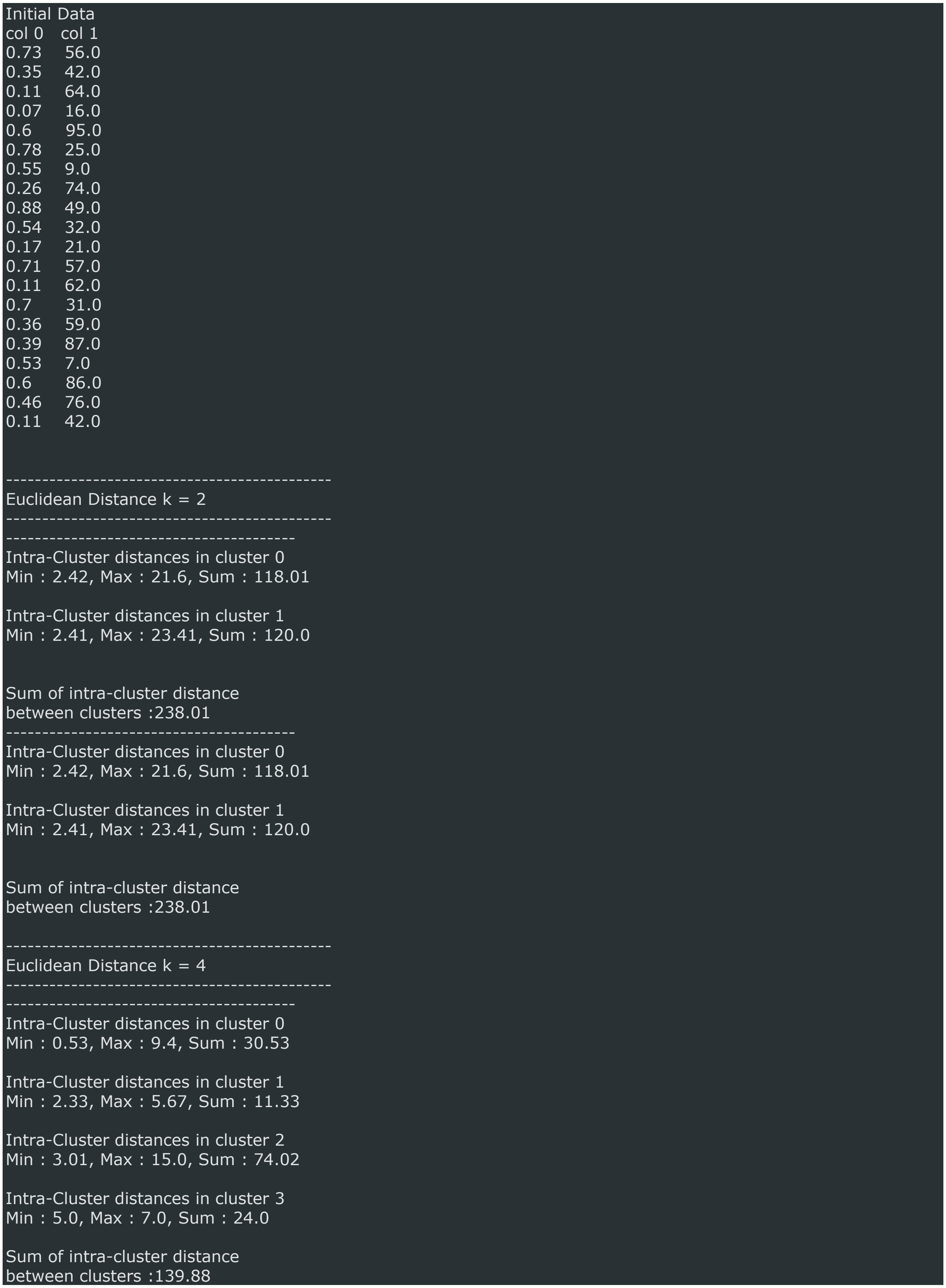
Kyu Cho
k-mean clustering with Java
3/15/16



```
Initial Data
col 0   col 1
0.73    56.0
0.35    42.0
0.11    64.0
0.07    16.0
0.6     95.0
0.78    25.0
0.55    9.0
0.26    74.0
0.88    49.0
0.54    32.0
0.17    21.0
0.71    57.0
0.11    62.0
0.7     31.0
0.36    59.0
0.39    87.0
0.53    7.0
0.6     86.0
0.46    76.0
0.11    42.0


--------------------------------------------
Euclidean Distance k = 2
--------------------------------------------
---------------------------------------
Intra-Cluster distances in cluster 0
Min : 2.42, Max : 21.6, Sum : 118.01

Intra-Cluster distances in cluster 1
Min : 2.41, Max : 23.41, Sum : 120.0


Sum of intra-cluster distance
between clusters :238.01
---------------------------------------
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Min : 2.42, Max : 21.6, Sum : 118.01

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Min : 2.41, Max : 23.41, Sum : 120.0


Sum of intra-cluster distance
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--------------------------------------------
Euclidean Distance k = 4
--------------------------------------------
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Intra-Cluster distances in cluster 0
Min : 0.53, Max : 9.4, Sum : 30.53

Intra-Cluster distances in cluster 1
Min : 2.33, Max : 5.67, Sum : 11.33

Intra-Cluster distances in cluster 2
Min : 3.01, Max : 15.0, Sum : 74.02

Intra-Cluster distances in cluster 3
Min : 5.0, Max : 7.0, Sum : 24.0

Sum of intra-cluster distance
between clusters :139.88
```

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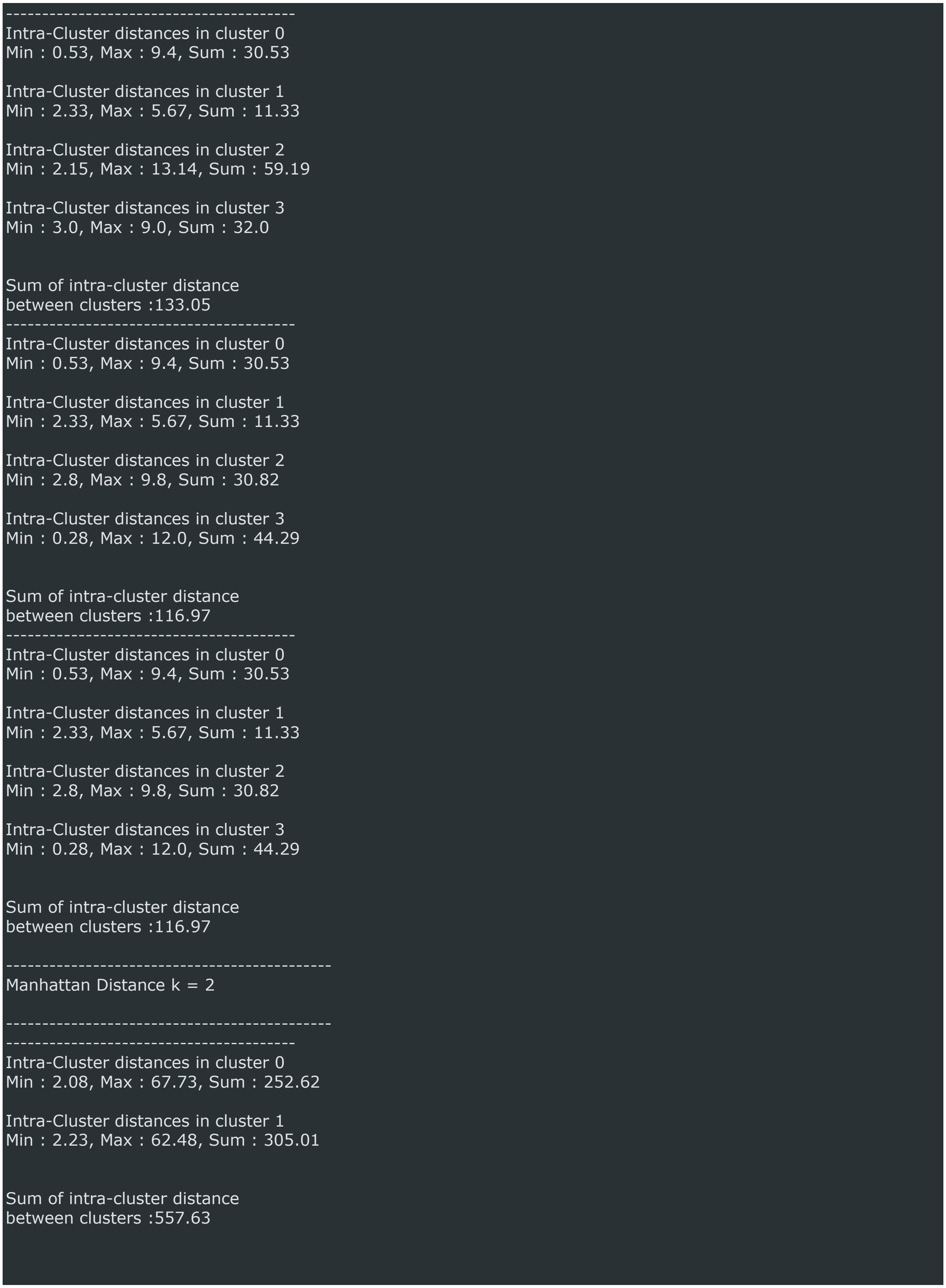

```
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Intra-Cluster distances in cluster 0
Min : 0.53, Max : 9.4, Sum : 30.53

Intra-Cluster distances in cluster 1
Min : 2.33, Max : 5.67, Sum : 11.33

Intra-Cluster distances in cluster 2
Min : 2.15, Max : 13.14, Sum : 59.19

Intra-Cluster distances in cluster 3
Min : 3.0, Max : 9.0, Sum : 32.0


Sum of intra-cluster distance
between clusters :133.05
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Intra-Cluster distances in cluster 0
Min : 0.53, Max : 9.4, Sum : 30.53

Intra-Cluster distances in cluster 1
Min : 2.33, Max : 5.67, Sum : 11.33

Intra-Cluster distances in cluster 2
Min : 2.8, Max : 9.8, Sum : 30.82

Intra-Cluster distances in cluster 3
Min : 0.28, Max : 12.0, Sum : 44.29


Sum of intra-cluster distance
between clusters :116.97
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Intra-Cluster distances in cluster 0
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Intra-Cluster distances in cluster 1
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Intra-Cluster distances in cluster 2
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Intra-Cluster distances in cluster 3
Min : 0.28, Max : 12.0, Sum : 44.29

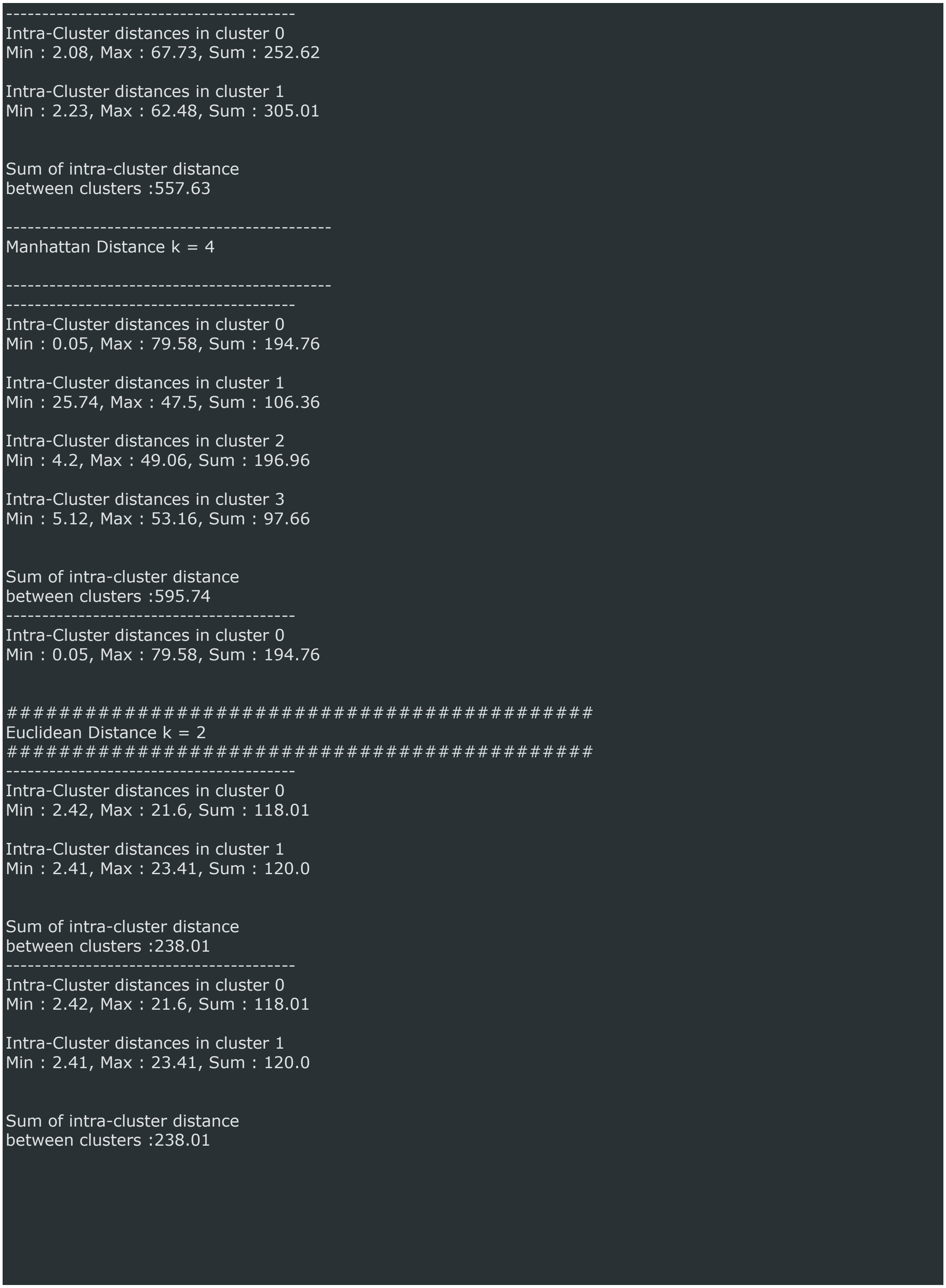

Sum of intra-cluster distance
between clusters :116.97

--------------------------------------------
Manhattan Distance k = 2

--------------------------------------------
----------------------------------------
Intra-Cluster distances in cluster 0
Min : 2.08, Max : 67.73, Sum : 252.62

Intra-Cluster distances in cluster 1
Min : 2.23, Max : 62.48, Sum : 305.01


Sum of intra-cluster distance
between clusters :557.63
```



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Intra-Cluster distances in cluster 0
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Intra-Cluster distances in cluster 1
Min : 2.23, Max : 62.48, Sum : 305.01


Sum of intra-cluster distance
between clusters :557.63

-------------------------------------------
Manhattan Distance k = 4

-------------------------------------------
--------------------------------------
Intra-Cluster distances in cluster 0
Min : 0.05, Max : 79.58, Sum : 194.76

Intra-Cluster distances in cluster 1
Min : 25.74, Max : 47.5, Sum : 106.36

Intra-Cluster distances in cluster 2
Min : 4.2, Max : 49.06, Sum : 196.96

Intra-Cluster distances in cluster 3
Min : 5.12, Max : 53.16, Sum : 97.66


Sum of intra-cluster distance
between clusters :595.74
--------------------------------------
Intra-Cluster distances in cluster 0
Min : 0.05, Max : 79.58, Sum : 194.76


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Euclidean Distance k = 2
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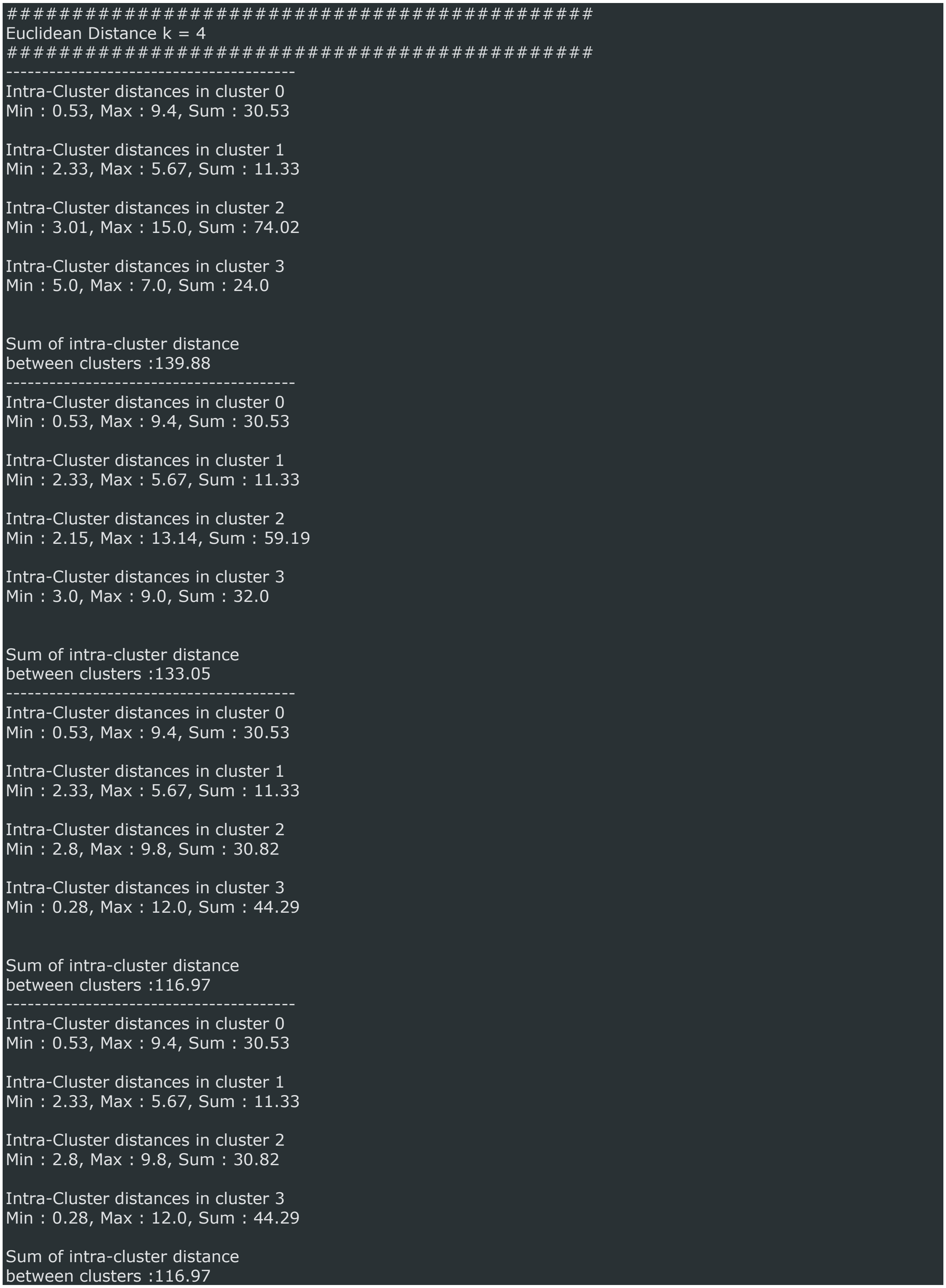

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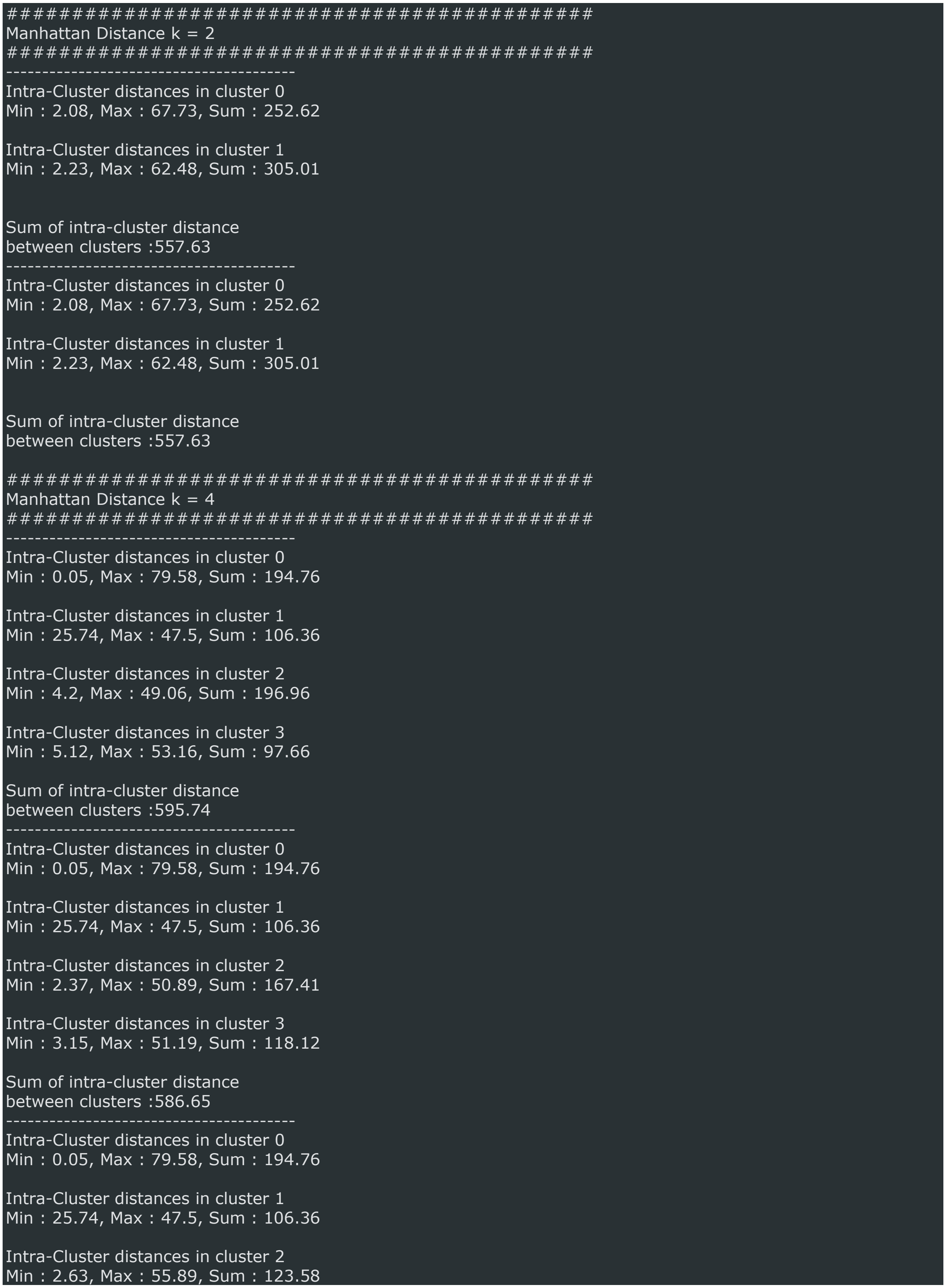

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Manhattan Distance k = 4
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between clusters :595.74
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Intra-Cluster distances in cluster 0
Min : 0.05, Max : 79.58, Sum : 194.76

Intra-Cluster distances in cluster 1
Min : 25.74, Max : 47.5, Sum : 106.36

Intra-Cluster distances in cluster 2
Min : 2.37, Max : 50.89, Sum : 167.41

Intra-Cluster distances in cluster 3
Min : 3.15, Max : 51.19, Sum : 118.12

Sum of intra-cluster distance
between clusters :586.65
---------------------------------------
Intra-Cluster distances in cluster 0
Min : 0.05, Max : 79.58, Sum : 194.76

Intra-Cluster distances in cluster 1
Min : 25.74, Max : 47.5, Sum : 106.36

Intra-Cluster distances in cluster 2
Min : 2.63, Max : 55.89, Sum : 123.58
```

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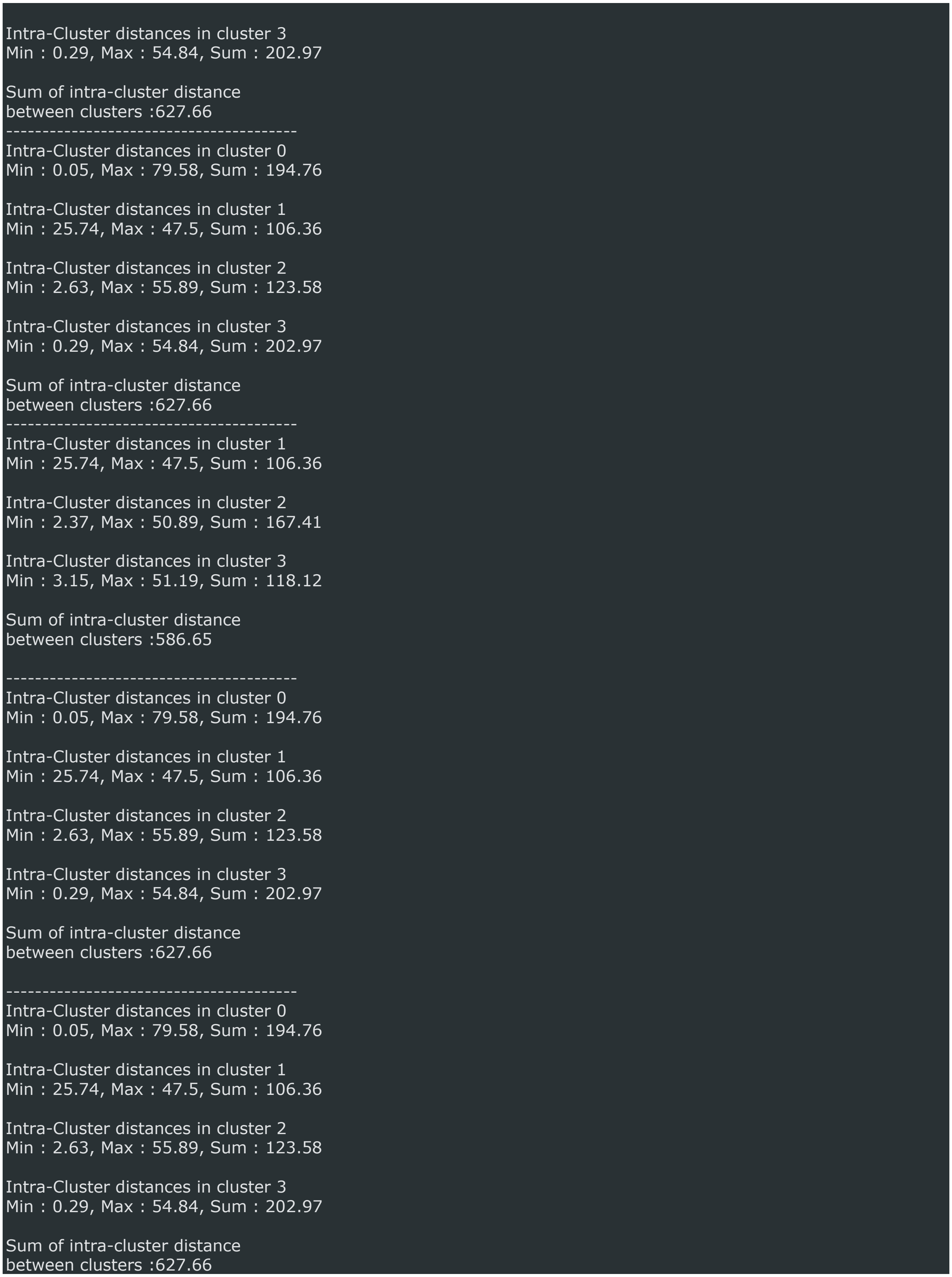

```
Intra-Cluster distances in cluster 3
Min : 0.29, Max : 54.84, Sum : 202.97

Sum of intra-cluster distance
between clusters :627.66
---------------------------------------
Intra-Cluster distances in cluster 0
Min : 0.05, Max : 79.58, Sum : 194.76

Intra-Cluster distances in cluster 1
Min : 25.74, Max : 47.5, Sum : 106.36

Intra-Cluster distances in cluster 2
Min : 2.63, Max : 55.89, Sum : 123.58

Intra-Cluster distances in cluster 3
Min : 0.29, Max : 54.84, Sum : 202.97

Sum of intra-cluster distance
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Intra-Cluster distances in cluster 3
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Sum of intra-cluster distance
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Sum of intra-cluster distance
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Intra-Cluster distances in cluster 2
Min : 2.63, Max : 55.89, Sum : 123.58

Intra-Cluster distances in cluster 3
Min : 0.29, Max : 54.84, Sum : 202.97

Sum of intra-cluster distance
between clusters :627.66
```

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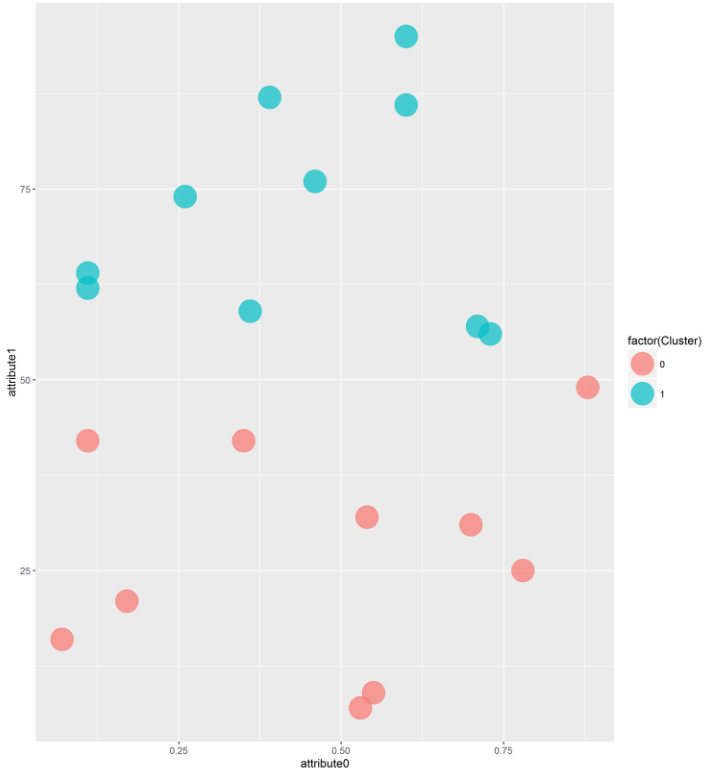
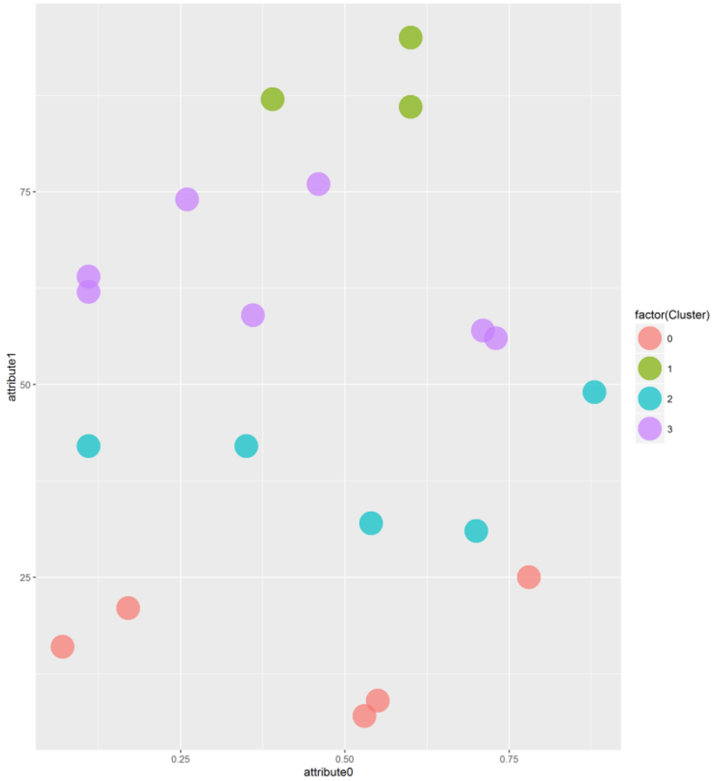
Euclidean Distance with k = 2



Euclidean Distance with k = 4



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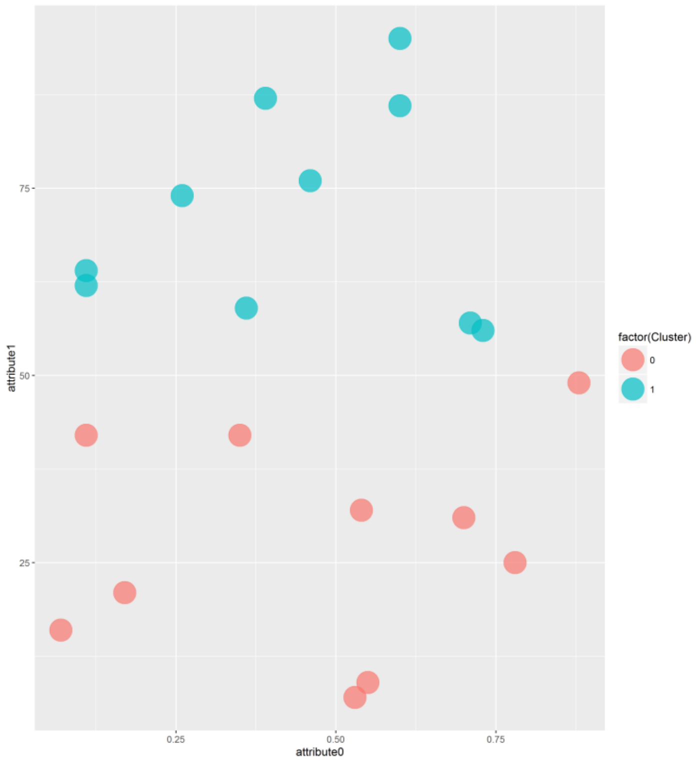
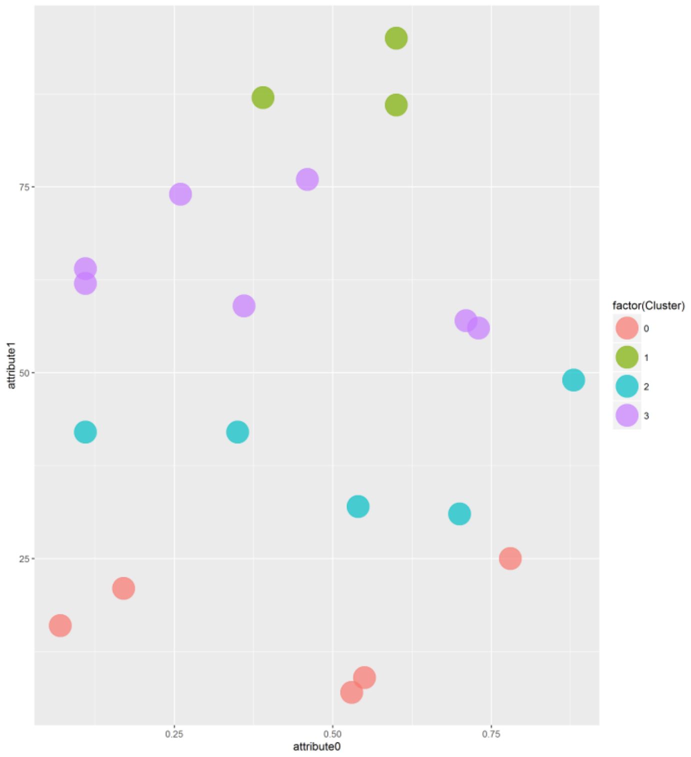
Manhattan Distance with k = 2



Manhattan Distance with k = 4



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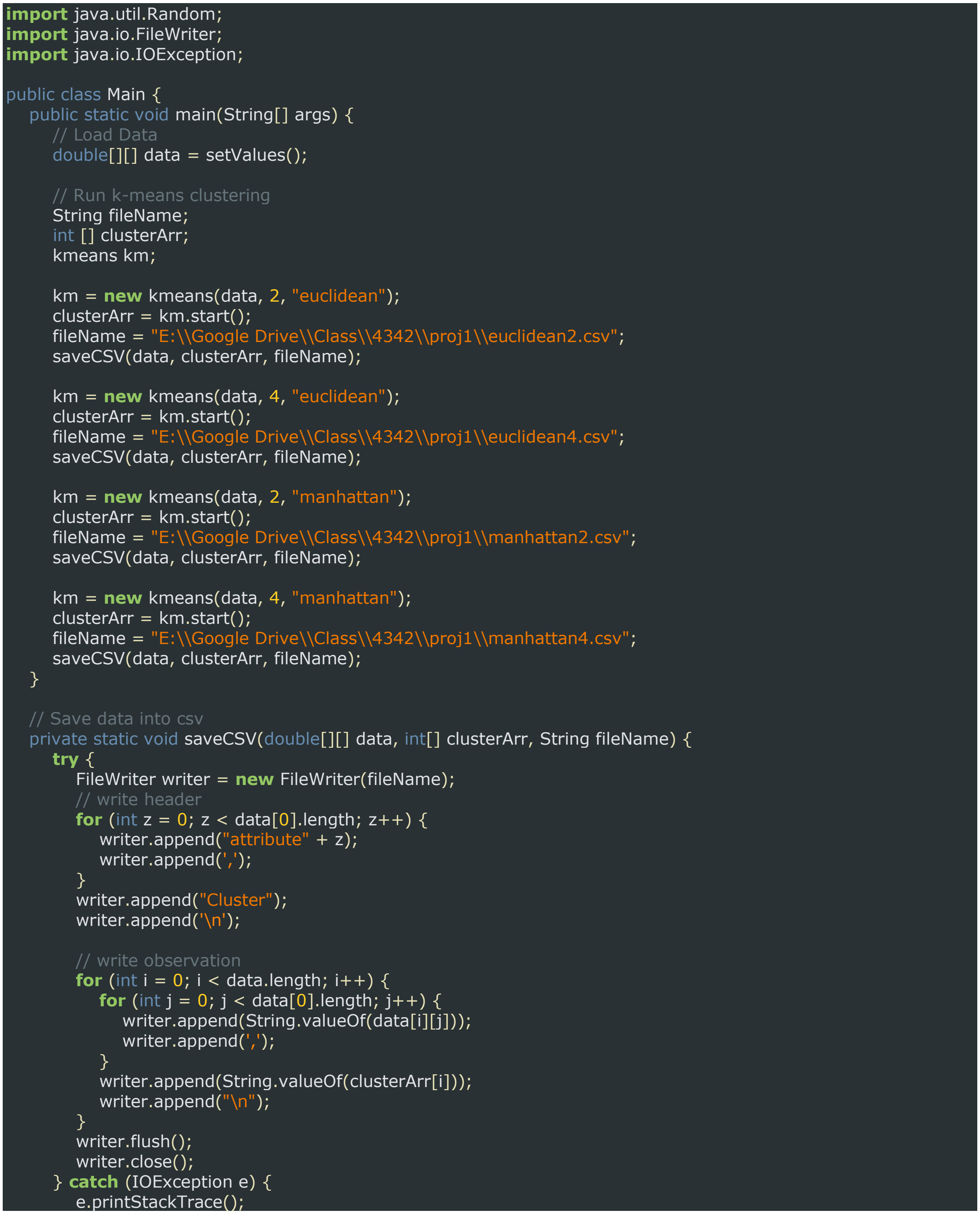
Source Code

Main.java



```java
import java.util.Random;
import java.io.FileWriter;
import java.io.IOException;

public class Main {
    public static void main(String[] args) {
        // Load Data
        double[][] data = setValues();

        // Run k-means clustering
        String fileName;
        int [] clusterArr;
        kmeans km;

        km = new kmeans(data, 2, "euclidean");
        clusterArr = km.start();
        fileName = "E:\\Google Drive\\Class\\4342\\proj1\\euclidean2.csv";
        saveCSV(data, clusterArr, fileName);

        km = new kmeans(data, 4, "euclidean");
        clusterArr = km.start();
        fileName = "E:\\Google Drive\\Class\\4342\\proj1\\euclidean4.csv";
        saveCSV(data, clusterArr, fileName);

        km = new kmeans(data, 2, "manhattan");
        clusterArr = km.start();
        fileName = "E:\\Google Drive\\Class\\4342\\proj1\\manhattan2.csv";
        saveCSV(data, clusterArr, fileName);

        km = new kmeans(data, 4, "manhattan");
        clusterArr = km.start();
        fileName = "E:\\Google Drive\\Class\\4342\\proj1\\manhattan4.csv";
        saveCSV(data, clusterArr, fileName);
    }

    // Save data into csv
    private static void saveCSV(double[][] data, int[] clusterArr, String fileName) {
        try {
            FileWriter writer = new FileWriter(fileName);
            // write header
            for (int z = 0; z < data[0].length; z++) {
                writer.append("attribute" + z);
                writer.append(',');
            }
            writer.append("Cluster");
            writer.append('\n');

            // write observation
            for (int i = 0; i < data.length; i++) {
                for (int j = 0; j < data[0].length; j++) {
                    writer.append(String.valueOf(data[i][j]));
                    writer.append(',');
                }
                writer.append(String.valueOf(clusterArr[i]));
                writer.append("\n");
            }
            writer.flush();
            writer.close();
        } catch (IOException e) {
            e.printStackTrace();
        }
    }

    // Arbitrarily generate random observations
    public static double[][] setValues() {
        int colLength = 2;
        int rowLength = 20;
        double [][] data = new double [rowLength][colLength];
        Random randnum = new Random(28);  // set seed

        for (int i = 0; i < rowLength; i++) {
            // Assign random numbers
            for (int j = 0; j < colLength; j++) {
                if (j == 0) data [i][j] = Math.floor(randnum.nextDouble() * 100.0)/ 100.0;
                else data [i][j] = Math.floor(randnum.nextDouble() * 100.0);
            }
        }

        // Print Data
        System.out.println("Initial Data");
        for (int j = 0; j < colLength; j++)
            System.out.print("col " + j + "\t");
        System.out.println("");
        for (int i = 0; i < rowLength; i++) {
            for (int j = 0; j < colLength; j++) {
                System.out.print(data[i][j]);
                System.out.print("\t");
            }
            System.out.println("");
        }
        System.out.println("");

        return data;
    }
}
```

Kmeans.java

```
import java.util.Random;

public class kmeans {
    public int k;
    public int rowLength;
    public int colLength;
    public int[] cluster;
    public double[][] data;
    public double[][] centroidDist;
    public double[][] intraDist;
    public double[][] centroid;
    public double[][] clustrMean;
    public double sumIntraDist;
    public boolean globalConverge;
    public String method;

    public kmeans (double[][] data, int k, String method) {
        this.data = data;
        this.k = k;
        this.method = method;
        this.rowLength = data.length;
        this.colLength = data[0].length;
        this.centroid = new double [k][colLength];
        this.centroidDist = new double [rowLength][k];
        this.cluster = new int [rowLength];
    }
```

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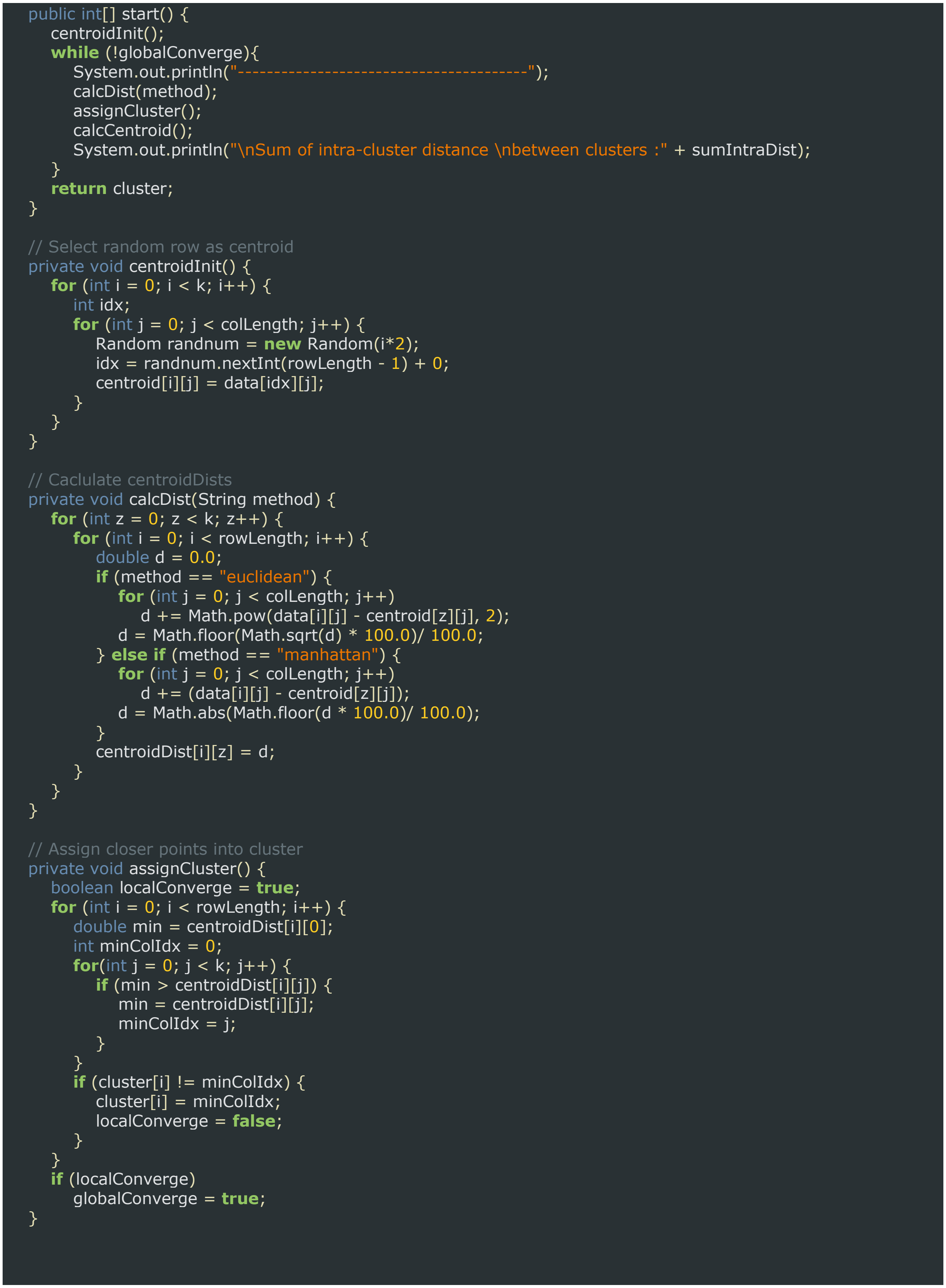
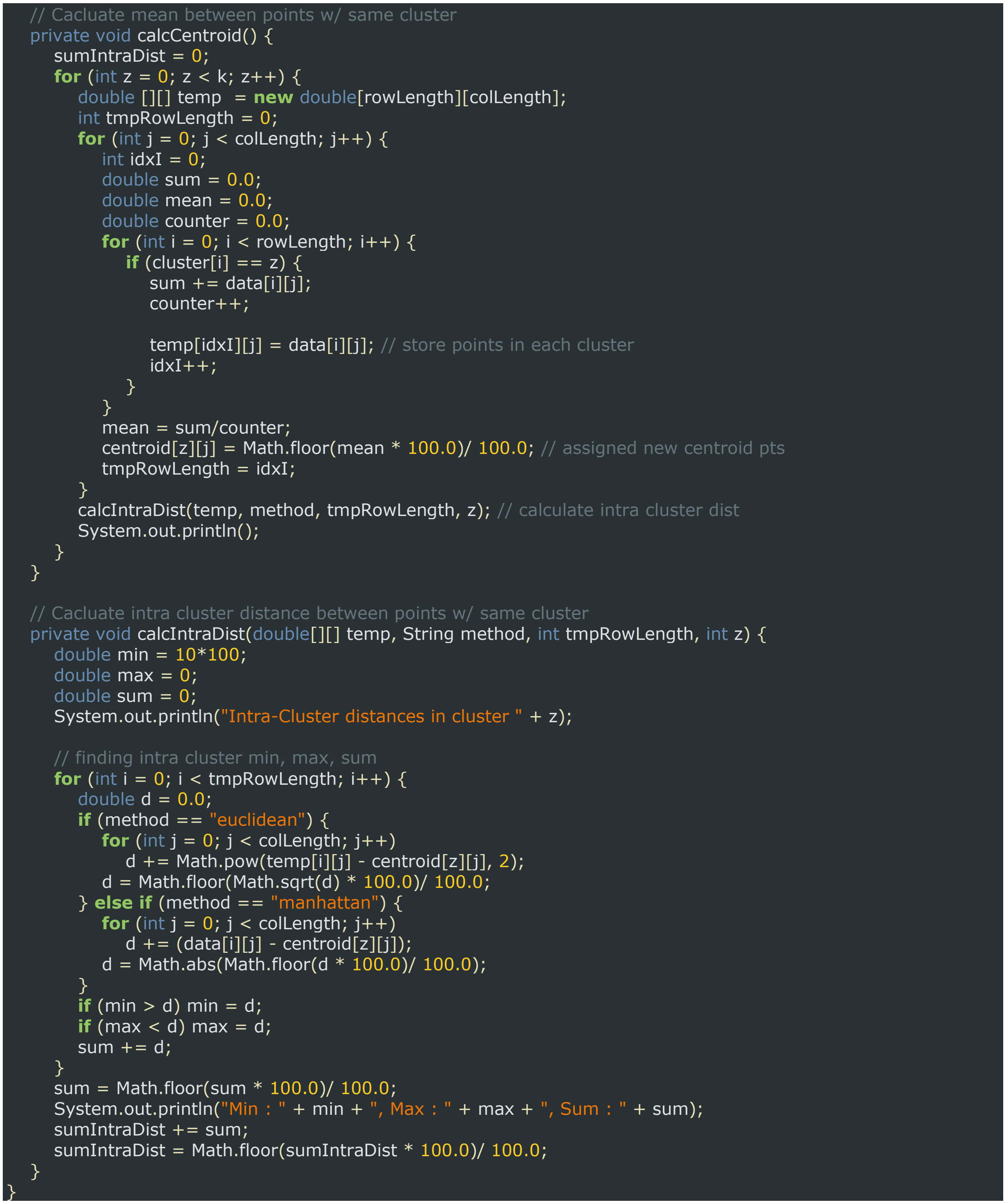


```java
public int[] start() {
    centroidInit();
    while (!globalConverge){
        System.out.println("----------------------------------------");
        calcDist(method);
        assignCluster();
        calcCentroid();
        System.out.println("\nSum of intra-cluster distance \nbetween clusters :" + sumIntraDist);
    }
    return cluster;
}

// Select random row as centroid
private void centroidInit() {
    for (int i = 0; i < k; i++) {
        int idx;
        for (int j = 0; j < colLength; j++) {
            Random randnum = new Random(i*2);
            idx = randnum.nextInt(rowLength - 1) + 0;
            centroid[i][j] = data[idx][j];
        }
    }
}

// Caclulate centroidDists
private void calcDist(String method) {
    for (int z = 0; z < k; z++) {
        for (int i = 0; i < rowLength; i++) {
            double d = 0.0;
            if (method == "euclidean") {
                for (int j = 0; j < colLength; j++)
                    d += Math.pow(data[i][j] - centroid[z][j], 2);
                d = Math.floor(Math.sqrt(d) * 100.0)/ 100.0;
            } else if (method == "manhattan") {
                for (int j = 0; j < colLength; j++)
                    d += (data[i][j] - centroid[z][j]);
                d = Math.abs(Math.floor(d * 100.0)/ 100.0);
            }
            centroidDist[i][z] = d;
        }
    }
}

// Assign closer points into cluster
private void assignCluster() {
    boolean localConverge = true;
    for (int i = 0; i < rowLength; i++) {
        double min = centroidDist[i][0];
        int minColIdx = 0;
        for(int j = 0; j < k; j++) {
            if (min > centroidDist[i][j]) {
                min = centroidDist[i][j];
                minColIdx = j;
            }
        }
        if (cluster[i] != minColIdx) {
            cluster[i] = minColIdx;
            localConverge = false;
        }
    }
    if (localConverge)
        globalConverge = true;
}
```



```
    // Cacluate mean between points w/ same cluster
    private void calcCentroid() {
        sumIntraDist = 0;
        for (int z = 0; z < k; z++) {
            double [][] temp  = new double[rowLength][colLength];
            int tmpRowLength = 0;
            for (int j = 0; j < colLength; j++) {
                int idxI = 0;
                double sum = 0.0;
                double mean = 0.0;
                double counter = 0.0;
                for (int i = 0; i < rowLength; i++) {
                    if (cluster[i] == z) {
                        sum += data[i][j];
                        counter++;

                        temp[idxI][j] = data[i][j]; // store points in each cluster
                        idxI++;
                    }
                }
                mean = sum/counter;
                centroid[z][j] = Math.floor(mean * 100.0)/ 100.0; // assigned new centroid pts
                tmpRowLength = idxI;
            }
            calcIntraDist(temp, method, tmpRowLength, z); // calculate intra cluster dist
            System.out.println();
        }
    }

    // Cacluate intra cluster distance between points w/ same cluster
    private void calcIntraDist(double[][] temp, String method, int tmpRowLength, int z) {
        double min = 10*100;
        double max = 0;
        double sum = 0;
        System.out.println("Intra-Cluster distances in cluster " + z);

        // finding intra cluster min, max, sum
        for (int i = 0; i < tmpRowLength; i++) {
            double d = 0.0;
            if (method == "euclidean") {
                for (int j = 0; j < colLength; j++)
                    d += Math.pow(temp[i][j] - centroid[z][j], 2);
                d = Math.floor(Math.sqrt(d) * 100.0)/ 100.0;
            } else if (method == "manhattan") {
                for (int j = 0; j < colLength; j++)
                    d += (data[i][j] - centroid[z][j]);
                d = Math.abs(Math.floor(d * 100.0)/ 100.0);
            }
            if (min > d) min = d;
            if (max < d) max = d;
            sum += d;
        }
        sum = Math.floor(sum * 100.0)/ 100.0;
        System.out.println("Min : " + min + ", Max : " + max + ", Sum : " + sum);
        sumIntraDist += sum;
        sumIntraDist = Math.floor(sumIntraDist * 100.0)/ 100.0;
    }
}
```

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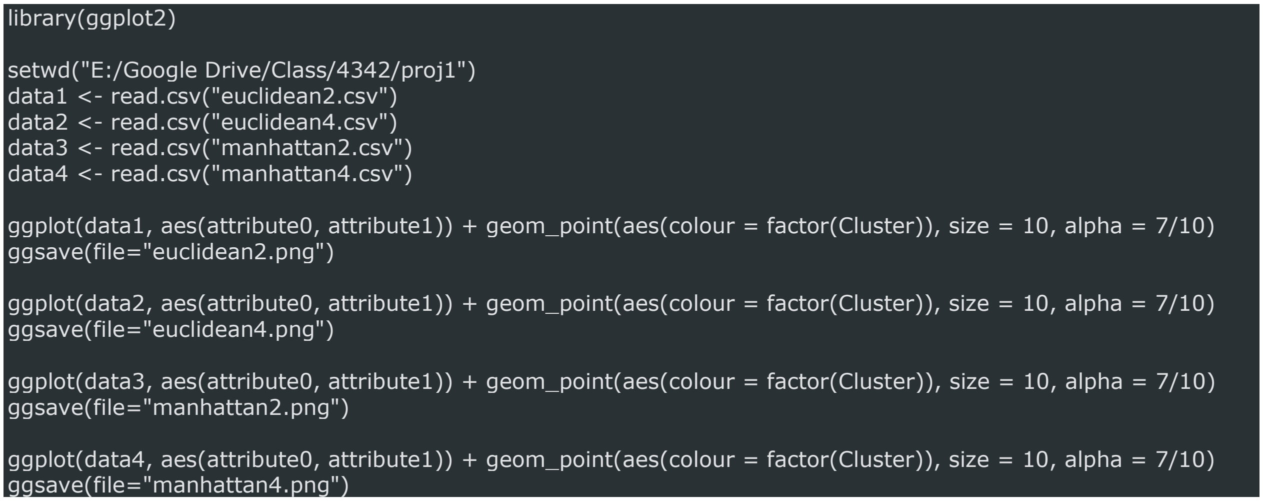
Plot.R



```
library(ggplot2)

setwd("E:/Google Drive/Class/4342/proj1")
data1 <- read.csv("euclidean2.csv")
data2 <- read.csv("euclidean4.csv")
data3 <- read.csv("manhattan2.csv")
data4 <- read.csv("manhattan4.csv")

ggplot(data1, aes(attribute0, attribute1)) + geom_point(aes(colour = factor(Cluster)), size = 10, alpha = 7/10)
ggsave(file="euclidean2.png")

ggplot(data2, aes(attribute0, attribute1)) + geom_point(aes(colour = factor(Cluster)), size = 10, alpha = 7/10)
ggsave(file="euclidean4.png")

ggplot(data3, aes(attribute0, attribute1)) + geom_point(aes(colour = factor(Cluster)), size = 10, alpha = 7/10)
ggsave(file="manhattan2.png")

ggplot(data4, aes(attribute0, attribute1)) + geom_point(aes(colour = factor(Cluster)), size = 10, alpha = 7/10)
ggsave(file="manhattan4.png")
```