Assignment\_5

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Due 4/17/2022

# ————————————————

# Following is the link to my GitHub account:

# <https://github.com/Kgardner22/64060_-kgardner>

# ————————————————

IMPORT THE DATA:

cereals.df <- read.csv('C:/R/MyData/Cereals.csv', header = T, sep = ',')   
  
summary(cereals.df)

## name mfr type calories   
## Length:77 Length:77 Length:77 Min. : 50.0   
## Class :character Class :character Class :character 1st Qu.:100.0   
## Mode :character Mode :character Mode :character Median :110.0   
## Mean :106.9   
## 3rd Qu.:110.0   
## Max. :160.0   
##   
## protein fat sodium fiber   
## Min. :1.000 Min. :0.000 Min. : 0.0 Min. : 0.000   
## 1st Qu.:2.000 1st Qu.:0.000 1st Qu.:130.0 1st Qu.: 1.000   
## Median :3.000 Median :1.000 Median :180.0 Median : 2.000   
## Mean :2.545 Mean :1.013 Mean :159.7 Mean : 2.152   
## 3rd Qu.:3.000 3rd Qu.:2.000 3rd Qu.:210.0 3rd Qu.: 3.000   
## Max. :6.000 Max. :5.000 Max. :320.0 Max. :14.000   
##   
## carbo sugars potass vitamins   
## Min. : 5.0 Min. : 0.000 Min. : 15.00 Min. : 0.00   
## 1st Qu.:12.0 1st Qu.: 3.000 1st Qu.: 42.50 1st Qu.: 25.00   
## Median :14.5 Median : 7.000 Median : 90.00 Median : 25.00   
## Mean :14.8 Mean : 7.026 Mean : 98.67 Mean : 28.25   
## 3rd Qu.:17.0 3rd Qu.:11.000 3rd Qu.:120.00 3rd Qu.: 25.00   
## Max. :23.0 Max. :15.000 Max. :330.00 Max. :100.00   
## NA's :1 NA's :1 NA's :2   
## shelf weight cups rating   
## Min. :1.000 Min. :0.50 Min. :0.250 Min. :18.04   
## 1st Qu.:1.000 1st Qu.:1.00 1st Qu.:0.670 1st Qu.:33.17   
## Median :2.000 Median :1.00 Median :0.750 Median :40.40   
## Mean :2.208 Mean :1.03 Mean :0.821 Mean :42.67   
## 3rd Qu.:3.000 3rd Qu.:1.00 3rd Qu.:1.000 3rd Qu.:50.83   
## Max. :3.000 Max. :1.50 Max. :1.500 Max. :93.70   
##

REMOVE ALL CEREALS WITH MISSING VALUES:

cereals.df <- na.omit(cereals.df) #Remove NA (missing) values

SET ROW NAMES IN THE DATAFRAME:

# set row names to the name column  
row.names(cereals.df) <- cereals.df[,1]  
  
# remove the name column as a variable  
cereals.df <- cereals.df[,-1]

NORMALIZE THE DATA:

# normalize all numeric variables (Columns 3 - 15)  
cereals.df.norm <- sapply(cereals.df[,c(3:15)], scale)  
  
# add row names: cereals  
row.names(cereals.df.norm) <- row.names(cereals.df)

APPLY HIERARCHICAL CLUSTERING USING AGNES AND FOUR LINKAGE MEASURES:

Apply hierarchical clustering to the data using Euclidean distance to the normalized measurements.

# load the cluster package so we can use agnes  
library(cluster)   
  
# compute normalized distance based on all numeric variables  
d.norm <- dist(cereals.df.norm, method = "euclidean")  
  
hc\_single <- agnes(d.norm, method = "single") # uses single linkage  
hc\_complete <- agnes(d.norm, method = "complete") #uses complete linkage  
hc\_average <- agnes(d.norm, method = "average") #uses average linkage  
hc\_ward <- agnes(d.norm, method = "ward") #uses Ward's method

COMPARE AGGLOMERATIVE COEFFICIENTS

print(hc\_single$ac)

## [1] 0.6067859

print(hc\_complete)

## Call: agnes(x = d.norm, method = "complete")   
## Agglomerative coefficient: 0.8353712   
## Order of objects:  
## [1] 100%\_Bran   
## [2] All-Bran   
## [3] All-Bran\_with\_Extra\_Fiber   
## [4] 100%\_Natural\_Bran   
## [5] Frosted\_Mini-Wheats   
## [6] Strawberry\_Fruit\_Wheats   
## [7] Raisin\_Squares   
## [8] Maypo   
## [9] Shredded\_Wheat   
## [10] Shredded\_Wheat\_'n'Bran   
## [11] Shredded\_Wheat\_spoon\_size   
## [12] Puffed\_Rice   
## [13] Puffed\_Wheat   
## [14] Apple\_Cinnamon\_Cheerios   
## [15] Honey\_Nut\_Cheerios   
## [16] Multi-Grain\_Cheerios   
## [17] Wheaties\_Honey\_Gold   
## [18] Frosted\_Flakes   
## [19] Golden\_Grahams   
## [20] Nut&Honey\_Crunch   
## [21] Cap'n'Crunch   
## [22] Honey\_Graham\_Ohs   
## [23] Cinnamon\_Toast\_Crunch   
## [24] Apple\_Jacks   
## [25] Corn\_Pops   
## [26] Cocoa\_Puffs   
## [27] Count\_Chocula   
## [28] Trix   
## [29] Fruity\_Pebbles   
## [30] Froot\_Loops   
## [31] Lucky\_Charms   
## [32] Golden\_Crisp   
## [33] Smacks   
## [34] Honey-comb   
## [35] Bran\_Chex   
## [36] Wheat\_Chex   
## [37] Wheaties   
## [38] Bran\_Flakes   
## [39] Grape\_Nuts\_Flakes   
## [40] Nutri-grain\_Wheat   
## [41] Grape-Nuts   
## [42] Clusters   
## [43] Raisin\_Nut\_Bran   
## [44] Cracklin'\_Oat\_Bran   
## [45] Great\_Grains\_Pecan   
## [46] Crispy\_Wheat\_&\_Raisins   
## [47] Life   
## [48] Quaker\_Oat\_Squares   
## [49] Cheerios   
## [50] Special\_K   
## [51] Corn\_Chex   
## [52] Rice\_Krispies   
## [53] Corn\_Flakes   
## [54] Rice\_Chex   
## [55] Kix   
## [56] Crispix   
## [57] Double\_Chex   
## [58] Triples   
## [59] Just\_Right\_Crunchy\_\_Nuggets   
## [60] Total\_Corn\_Flakes   
## [61] Total\_Whole\_Grain   
## [62] Product\_19   
## [63] Basic\_4   
## [64] Nutri-Grain\_Almond-Raisin   
## [65] Mueslix\_Crispy\_Blend   
## [66] Fruit\_&\_Fibre\_Dates,\_Walnuts,\_and\_Oats  
## [67] Oatmeal\_Raisin\_Crisp   
## [68] Muesli\_Raisins,\_Dates,\_&\_Almonds   
## [69] Muesli\_Raisins,\_Peaches,\_&\_Pecans   
## [70] Fruitful\_Bran   
## [71] Post\_Nat.\_Raisin\_Bran   
## [72] Raisin\_Bran   
## [73] Just\_Right\_Fruit\_&\_Nut   
## [74] Total\_Raisin\_Bran   
## Height (summary):  
## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 0.1431 1.6076 2.3389 2.9321 3.7169 10.9839   
##   
## Available components:  
## [1] "order" "height" "ac" "merge" "diss" "call"   
## [7] "method" "order.lab"

print(hc\_average)

## Call: agnes(x = d.norm, method = "average")   
## Agglomerative coefficient: 0.7766075   
## Order of objects:  
## [1] 100%\_Bran   
## [2] All-Bran   
## [3] All-Bran\_with\_Extra\_Fiber   
## [4] 100%\_Natural\_Bran   
## [5] Apple\_Cinnamon\_Cheerios   
## [6] Honey\_Nut\_Cheerios   
## [7] Multi-Grain\_Cheerios   
## [8] Wheaties\_Honey\_Gold   
## [9] Frosted\_Flakes   
## [10] Golden\_Grahams   
## [11] Nut&Honey\_Crunch   
## [12] Apple\_Jacks   
## [13] Corn\_Pops   
## [14] Cocoa\_Puffs   
## [15] Count\_Chocula   
## [16] Trix   
## [17] Froot\_Loops   
## [18] Lucky\_Charms   
## [19] Fruity\_Pebbles   
## [20] Golden\_Crisp   
## [21] Smacks   
## [22] Cap'n'Crunch   
## [23] Honey\_Graham\_Ohs   
## [24] Cinnamon\_Toast\_Crunch   
## [25] Honey-comb   
## [26] Bran\_Chex   
## [27] Wheat\_Chex   
## [28] Wheaties   
## [29] Bran\_Flakes   
## [30] Grape-Nuts   
## [31] Crispix   
## [32] Double\_Chex   
## [33] Triples   
## [34] Grape\_Nuts\_Flakes   
## [35] Nutri-grain\_Wheat   
## [36] Clusters   
## [37] Raisin\_Nut\_Bran   
## [38] Cracklin'\_Oat\_Bran   
## [39] Great\_Grains\_Pecan   
## [40] Life   
## [41] Quaker\_Oat\_Squares   
## [42] Crispy\_Wheat\_&\_Raisins   
## [43] Corn\_Chex   
## [44] Rice\_Krispies   
## [45] Corn\_Flakes   
## [46] Rice\_Chex   
## [47] Kix   
## [48] Frosted\_Mini-Wheats   
## [49] Strawberry\_Fruit\_Wheats   
## [50] Raisin\_Squares   
## [51] Maypo   
## [52] Shredded\_Wheat   
## [53] Shredded\_Wheat\_'n'Bran   
## [54] Shredded\_Wheat\_spoon\_size   
## [55] Basic\_4   
## [56] Nutri-Grain\_Almond-Raisin   
## [57] Oatmeal\_Raisin\_Crisp   
## [58] Mueslix\_Crispy\_Blend   
## [59] Fruit\_&\_Fibre\_Dates,\_Walnuts,\_and\_Oats  
## [60] Fruitful\_Bran   
## [61] Post\_Nat.\_Raisin\_Bran   
## [62] Raisin\_Bran   
## [63] Muesli\_Raisins,\_Dates,\_&\_Almonds   
## [64] Muesli\_Raisins,\_Peaches,\_&\_Pecans   
## [65] Just\_Right\_Crunchy\_\_Nuggets   
## [66] Total\_Corn\_Flakes   
## [67] Total\_Whole\_Grain   
## [68] Product\_19   
## [69] Just\_Right\_Fruit\_&\_Nut   
## [70] Total\_Raisin\_Bran   
## [71] Cheerios   
## [72] Special\_K   
## [73] Puffed\_Rice   
## [74] Puffed\_Wheat   
## Height (summary):  
## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 0.1431 1.4633 2.0666 2.4461 2.9445 7.7243   
##   
## Available components:  
## [1] "order" "height" "ac" "merge" "diss" "call"   
## [7] "method" "order.lab"

print(hc\_ward)

## Call: agnes(x = d.norm, method = "ward")   
## Agglomerative coefficient: 0.9046042   
## Order of objects:  
## [1] 100%\_Bran   
## [2] All-Bran   
## [3] All-Bran\_with\_Extra\_Fiber   
## [4] 100%\_Natural\_Bran   
## [5] Muesli\_Raisins,\_Dates,\_&\_Almonds   
## [6] Muesli\_Raisins,\_Peaches,\_&\_Pecans   
## [7] Clusters   
## [8] Raisin\_Nut\_Bran   
## [9] Cracklin'\_Oat\_Bran   
## [10] Great\_Grains\_Pecan   
## [11] Crispy\_Wheat\_&\_Raisins   
## [12] Life   
## [13] Quaker\_Oat\_Squares   
## [14] Basic\_4   
## [15] Nutri-Grain\_Almond-Raisin   
## [16] Mueslix\_Crispy\_Blend   
## [17] Fruit\_&\_Fibre\_Dates,\_Walnuts,\_and\_Oats  
## [18] Oatmeal\_Raisin\_Crisp   
## [19] Fruitful\_Bran   
## [20] Post\_Nat.\_Raisin\_Bran   
## [21] Raisin\_Bran   
## [22] Just\_Right\_Fruit\_&\_Nut   
## [23] Total\_Raisin\_Bran   
## [24] Apple\_Cinnamon\_Cheerios   
## [25] Honey\_Nut\_Cheerios   
## [26] Multi-Grain\_Cheerios   
## [27] Wheaties\_Honey\_Gold   
## [28] Frosted\_Flakes   
## [29] Golden\_Grahams   
## [30] Nut&Honey\_Crunch   
## [31] Cap'n'Crunch   
## [32] Honey\_Graham\_Ohs   
## [33] Cinnamon\_Toast\_Crunch   
## [34] Apple\_Jacks   
## [35] Corn\_Pops   
## [36] Golden\_Crisp   
## [37] Smacks   
## [38] Cocoa\_Puffs   
## [39] Count\_Chocula   
## [40] Trix   
## [41] Fruity\_Pebbles   
## [42] Froot\_Loops   
## [43] Lucky\_Charms   
## [44] Honey-comb   
## [45] Bran\_Chex   
## [46] Wheat\_Chex   
## [47] Wheaties   
## [48] Bran\_Flakes   
## [49] Grape\_Nuts\_Flakes   
## [50] Nutri-grain\_Wheat   
## [51] Grape-Nuts   
## [52] Crispix   
## [53] Double\_Chex   
## [54] Triples   
## [55] Cheerios   
## [56] Special\_K   
## [57] Corn\_Chex   
## [58] Rice\_Krispies   
## [59] Corn\_Flakes   
## [60] Rice\_Chex   
## [61] Kix   
## [62] Just\_Right\_Crunchy\_\_Nuggets   
## [63] Total\_Corn\_Flakes   
## [64] Total\_Whole\_Grain   
## [65] Product\_19   
## [66] Frosted\_Mini-Wheats   
## [67] Strawberry\_Fruit\_Wheats   
## [68] Raisin\_Squares   
## [69] Maypo   
## [70] Shredded\_Wheat   
## [71] Shredded\_Wheat\_'n'Bran   
## [72] Shredded\_Wheat\_spoon\_size   
## [73] Puffed\_Rice   
## [74] Puffed\_Wheat   
## Height (summary):  
## Min. 1st Qu. Median Mean 3rd Qu. Max.   
## 0.1431 1.5858 2.3422 3.6092 4.1559 18.5749   
##   
## Available components:  
## [1] "order" "height" "ac" "merge" "diss" "call"   
## [7] "method" "order.lab"

COMPARE THE RESULTS:

Compare the results of the Agglomerative coefficients (AC) of the four methods.

Single Linkage (hc\_single): AC = 0.6067859

Complete Linkage (hc\_complete): AC = 0.8353712

Average Linkage (hc\_average): AC = 0.7766075

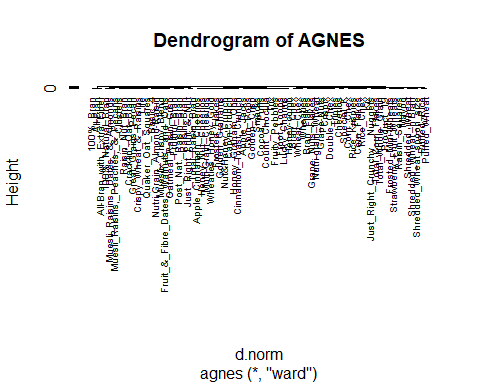
Ward’s Method (hc\_ward): AC = 0.9046042

In comparing the Agglomerative coefficients (AC), we see Ward’s Method is the best linkage method as it results in the highest Agglomeritve coefficient value.

PLOT THE DENDROGRAM:

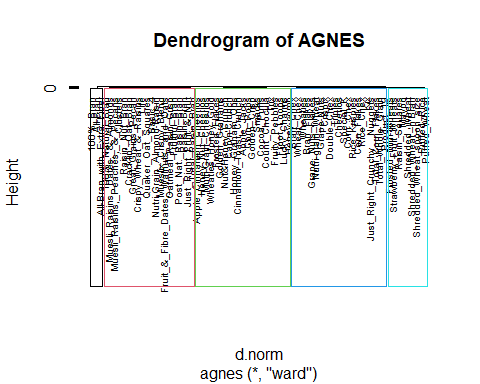
To help answer the question of “how many clusters would you choose”, let’s first review the dendrogram using Ward’s Method for hierarchical clustering since this proved to be the best linkage method.

pltree(hc\_ward, cex = 0.6, hang = -1, main = "Dendrogram of AGNES")

 In reviewing the dendrogram, the cereals appear to fall logically into five (5) clusters by setting a cutoff of 12.

Let’s now visualize the five (5) clusters:

pltree(hc\_ward, cex = 0.6, hang = -1, main = "Dendrogram of AGNES")  
rect.hclust(hc\_ward, k=5, border = 1:5)



COMPUTE CLUSTER MEMBERSHIP BY “CUTTING” THE DENDROGRAM

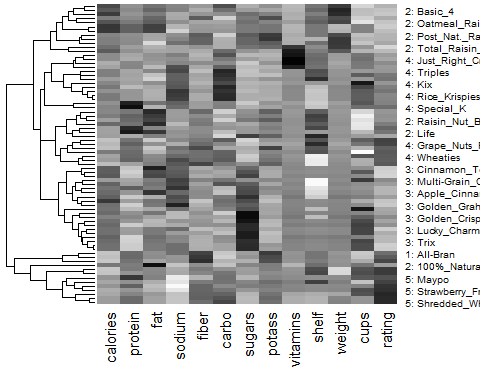
memb <- cutree(hc\_ward, k = 5)  
memb

## [1] 1 2 1 1 3 3 2 4 4 3 4 3 2 3 4 4 3 3 2 4 2 4 3 3 5 2 2 3 3 3 4 4 2 3 3 3 4 2  
## [39] 4 2 3 5 2 2 2 3 3 2 4 2 2 4 5 5 2 2 2 5 4 4 5 5 5 3 4 5 4 2 4 4 3 4 4 3

CREATING A HEATMAP

The following will create a heatmap for the 74 cereals (in rows). The rows are sorted by the five clusters from the Ward linkage clustering. Darker cells denote higher values within a column

# set labels as cluster membership and cereal name  
row.names(cereals.df.norm) <- paste(memb, ": ", row.names(cereals.df), sep = "")  
  
# plot heatmap   
# rev() reverses the color mapping to large = dark  
heatmap(as.matrix(cereals.df.norm), Colv = NA,   
 col=rev(paste("gray",1:99,sep="")))



INTERPRETING THE DATA:

In reviewing the 13 variables for all 74 cereals by cluster, we can identify the following cluster commonalities:

Cluster 1: High in Fiber and Potassium with good customer satisfaction rating Cluster 2: High in Calories and Fat (and lowest in Vitamins) Cluster 3: High in Sugars and Calories Cluster 4: High in Carbohydrates (“Carbs”) and slightly higher in Sodium Cluster 5: Higher in Protein, Fiber, Carbs, and Potassium and highest in Customer Satisfaction Rating

The elementary public schools would like to identify a group/cluster of “healthy cereals” to include in their daily cafeterias. To make this recommendation, we first need to understand which factors are desirable to consider a cereal “healthy”.

A google search reveals “healthy cereals” should include: \* Whole grains \* High in Fiber, protein and nutrients/vitamins \* Carbs are a main source of energy and help fuel our brains and vital organs

Based on our above interpretation of the five (5) clusters, the healthiest group of cereals is:

Cluster 5:  
 This cluster has higher levels of protein, fiber, carbs, and potassium while having the highest  
 customer satisfaction ratings. There are nine cereals in this grouping providing a good selection  
 of "healthy cereals" for elementary children.