**CS5900/STAT 46700 Topics in Data Science Spring 2025**

**Lab 9**

1. The penguins dataset included in the palmerpenguins package provides the size measurements for adult foraging penguins near Palmer Station, Antarctica.
2. Access the data and determine its dimension.
3. How many species of penguins are provided in the dataset?
4. Extract the variables bill\_length\_mm and flipper\_length\_mm and the corresponding species.
5. Calculate standard scores of both variables bill\_length\_mm and flipper\_length\_mm
6. Determine the beat value of k to choose k means cluster.
7. Create the number of clusters per the recommendation of part (e) and determine the size of the in each cluster.
8. Calculate the center of each cluster
9. Assess the performance of the cluster analysis.

> # Lab 9

> # 1

> # a

> install.packages("palmerpenguins")

> library(palmerpenguins)

> data(penguins, package = "palmerpenguins")

> head(penguins)

# A tibble: 6 × 8

species island bill\_length\_mm bill\_depth\_mm flipper\_length\_mm body\_mass\_g sex year

*<fct>* *<fct>* *<dbl>* *<dbl>* *<int>* *<int>* *<fct>* *<int>*

1 Adelie Torgersen 39.1 18.7 181 3750 male 2007

2 Adelie Torgersen 39.5 17.4 186 3800 female 2007

3 Adelie Torgersen 40.3 18 195 3250 female 2007

4 Adelie Torgersen NA NA NA NA NA 2007

5 Adelie Torgersen 36.7 19.3 193 3450 female 2007

6 Adelie Torgersen 39.3 20.6 190 3650 male 2007

> dim(penguins)

[1] 344 8

> # b

> names(penguins)

[1] "species" "island" "bill\_length\_mm" "bill\_depth\_mm"

[5] "flipper\_length\_mm" "body\_mass\_g" "sex" "year"

> attach(penguins)

> table(species)

species

Adelie Chinstrap Gentoo

152 68 124

> cat("There are 3 species of penguins in the given dataset")

There are 3 species of penguins in the given dataset

> # c

> new = penguins[,c(1,3,5)]

> head(new)

# A tibble: 6 × 3

species bill\_length\_mm flipper\_length\_mm

*<fct>* *<dbl>* *<int>*

1 Adelie 39.1 181

2 Adelie 39.5 186

3 Adelie 40.3 195

4 Adelie NA NA

5 Adelie 36.7 193

6 Adelie 39.3 190

> dim(new)

[1] 344 3

> names(new)

[1] "species" "bill\_length\_mm" "flipper\_length\_mm"

> cleandata <- na.omit(new)

> head(cleandata)

# A tibble: 6 × 3

species bill\_length\_mm flipper\_length\_mm

*<fct>* *<dbl>* *<int>*

1 Adelie 39.1 181

2 Adelie 39.5 186

3 Adelie 40.3 195

4 Adelie 36.7 193

5 Adelie 39.3 190

6 Adelie 38.9 181

> dim(cleandata)

[1] 342 3

> # also

> needed\_data <- cleandata[,c(2,3)]

> head(needed\_data)

# A tibble: 6 × 2

bill\_length\_mm flipper\_length\_mm

*<dbl>* *<int>*

1 39.1 181

2 39.5 186

3 40.3 195

4 36.7 193

5 39.3 190

6 38.9 181

> dim(needed\_data)

[1] 342 2

> class = cleandata$species

> head(class)

[1] Adelie Adelie Adelie Adelie Adelie Adelie

Levels: Adelie Chinstrap Gentoo

> length(class)

[1] 342

> class

[1] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[10] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[19] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[28] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[37] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[46] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[55] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[64] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[73] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[82] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[91] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[100] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[109] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[118] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[127] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[136] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie Adelie

[145] Adelie Adelie Adelie Adelie Adelie Adelie Adelie Gentoo Gentoo

[154] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[163] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[172] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[181] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[190] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[199] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[208] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[217] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[226] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[235] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[244] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[253] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[262] Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo Gentoo

[271] Gentoo Gentoo Gentoo Gentoo Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

[280] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

[289] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

[298] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

[307] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

[316] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

[325] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

[334] Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap Chinstrap

Levels: Adelie Chinstrap Gentoo

> # d

> data1 <- scale(needed\_data)

> head(data1)

bill\_length\_mm flipper\_length\_mm

[1,] -0.8832047 -1.4162715

[2,] -0.8099390 -1.0606961

[3,] -0.6634077 -0.4206603

[4,] -1.3227986 -0.5628905

[5,] -0.8465718 -0.7762357

[6,] -0.9198375 -1.4162715

> # e

> install.packages("factoextra")

> library(factoextra)

> fviz\_nbclust(data1, kmeans, method="wss")

> cat("From the plot, 3 or 4 is the best cluster count")

From the plot, 3 or 4 is the best cluster count

A graph with a blue line

AI-generated content may be incorrect.

> # f

> result = kmeans(data1,3)

> result$size

[1] 64 127 151

> result

K-means clustering with 3 clusters of sizes 64, 127, 151

Cluster means:

bill\_length\_mm flipper\_length\_mm

1 0.9367029 -0.3695463

2 0.6656141 1.1461115

3 -0.9568342 -0.8073192

Clustering vector:

[1] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3

[46] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

[91] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 3

[136] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[181] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[226] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[271] 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 1 3 1 1 1 1 1 1 1 3 1 3 1 1 1 1 2 1 1 2

[316] 1 1 1 1 1 1 2 1 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 1 1 2 1

Within cluster sum of squares by cluster:

[1] 29.51333 66.51303 61.32751

(between\_SS / total\_SS = 76.9 %)

Available components:

[1] "cluster" "centers" "totss" "withinss" "tot.withinss" "betweenss"

[7] "size" "iter" "ifault"

> cat("For 3 clusters: 127 151 64")

For 3 clusters: 127 151 64

>

>

>

> result1 = kmeans(data1,4)

> result1$size

[1] 62 149 50 81

> result1

K-means clustering with 4 clusters of sizes 62, 149, 50, 81

Cluster means:

bill\_length\_mm flipper\_length\_mm

1 0.9330747 -0.3896908

2 -0.9623709 -0.8234867

3 1.2356382 1.5250485

4 0.2933423 0.8717028

Clustering vector:

[1] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2

[46] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[91] 4 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2

[136] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 3 4 3 4 4 4 4 4 4 4 3 4 4 4 3 4 3 4 3 3 4 4 4 4 4 4 4 4

[181] 3 3 4 4 3 3 3 4 4 4 4 4 3 4 3 3 4 4 3 4 4 4 3 4 3 4 4 4 4 4 3 4 4 4 3 4 3 4 3 4 3 4 4 3 4

[226] 4 3 4 3 4 4 4 3 4 3 4 3 4 3 4 3 4 3 4 3 4 3 3 4 1 3 3 3 4 3 4 4 4 3 4 4 3 3 4 3 4 3 4 3 4

[271] 4 3 4 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 1 1 1 1 1 1 1 2 1 2 1 1 1 1 3 1 1 4

[316] 1 1 1 1 1 1 4 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 3 4 1 3 1

Within cluster sum of squares by cluster:

[1] 26.08107 58.01789 16.93993 17.38010

(between\_SS / total\_SS = 82.6 %)

Available components:

[1] "cluster" "centers" "totss" "withinss" "tot.withinss" "betweenss"

[7] "size" "iter" "ifault"

> cat("For 4 clusters: 41 116 116 69")

For 4 clusters: 41 116 116 69

> # g

> # For 3 clusters

> result$centers

bill\_length\_mm flipper\_length\_mm

1 0.9367029 -0.3695463

2 0.6656141 1.1461115

3 -0.9568342 -0.8073192

> result$cluster

[1] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3

[46] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

[91] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 3

[136] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[181] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[226] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[271] 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 3 1 3 1 1 1 1 1 1 1 3 1 3 1 1 1 1 2 1 1 2

[316] 1 1 1 1 1 1 2 1 1 1 1 1 1 3 1 1 1 1 1 1 1 1 1 1 1 2 1

> result$size

[1] 64 127 151

>

>

>

> # For 4 clusters

> result1$centers

bill\_length\_mm flipper\_length\_mm

1 0.9330747 -0.3896908

2 -0.9623709 -0.8234867

3 1.2356382 1.5250485

4 0.2933423 0.8717028

> result1$cluster

[1] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2

[46] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[91] 4 2 2 2 4 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 2 2 2 2 2 2

[136] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 3 4 3 4 4 4 4 4 4 4 3 4 4 4 3 4 3 4 3 3 4 4 4 4 4 4 4 4

[181] 3 3 4 4 3 3 3 4 4 4 4 4 3 4 3 3 4 4 3 4 4 4 3 4 3 4 4 4 4 4 3 4 4 4 3 4 3 4 3 4 3 4 4 3 4

[226] 4 3 4 3 4 4 4 3 4 3 4 3 4 3 4 3 4 3 4 3 4 3 3 4 1 3 3 3 4 3 4 4 4 3 4 4 3 3 4 3 4 3 4 3 4

[271] 4 3 4 3 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 2 1 2 1 1 1 1 1 1 1 2 1 2 1 1 1 1 3 1 1 4

[316] 1 1 1 1 1 1 4 1 1 1 1 1 1 2 1 1 1 1 1 1 1 1 3 4 1 3 1

> result1$size

[1] 62 149 50 81

> # h

> result$cluster

[1] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3

[49] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

[97] 3 3 3 3 3 3 3 3 3 3 3 3 3 3 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3 2 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3

[145] 3 3 3 3 3 3 3 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[193] 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2

[241] 2 2 2 2 2 2 2 2 2 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1

[289] 1 1 1 1 1 1 3 1 3 1 1 1 1 1 1 1 3 1 3 1 1 1 1 2 1 1 2 1 1 1 1 1 1 2 1 1 1 1 1 1 3 1 1 1 1 1 1 1

[337] 1 1 1 1 2 1

> length(result$cluster)

[1] 342

> table(result$cluster, class)

class

Adelie Chinstrap Gentoo

1 4 59 1

2 1 4 122

3 146 5 0

> table(class)

class

Adelie Chinstrap Gentoo

151 68 123

> cat("Thus, we can see that: FOR 3 CLUSTER SYSTEM

+ 1. Out of 151 actual Adelie species, 146 were correctly identified and rest 5 were wrongly identified.

+ 2. Out of 68 actual Chinstrap species, 59 were correctly identified and rest 9 were wrongly identified.

+ 3. Out of 123 actual Gentoo species, 122 were correctly identified and rest 1 is wrongly identified.")

Thus, we can see that: FOR 3 CLUSTER SYSTEM

1. Out of 151 actual Adelie species, 146 were correctly identified and rest 5 were wrongly identified.

2. Out of 68 actual Chinstrap species, 59 were correctly identified and rest 9 were wrongly identified.

3. Out of 123 actual Gentoo species, 122 were correctly identified and rest 1 is wrongly identified.